Caloric Diet Intake and Nutrition: What Happens

By

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INTRODUCTION

Humans eat to live. That's the basic fact of life. One of the reasons we "learned" in grade school perhaps, was to be strong like dad or pretty like mon. Actually we eat because we need the electrons and hydrogens contained in foods to ultimately make biological energy in the form of *ATP*.[1] We also need the *vitamins* in foods we eat because without them we cannot process those foods and vitamin deficiencies lead to illnesses. The problem is that eating is as much a social activity as it is a biologically necessary activity. There are certain times of the year where it appears as a near requirement of various special occasions, such as Easter, Thanksgiving, Christmas, and New Year day. And then there are some foods which are so good, flavorful, sweet, delicious, even "comforting." It may be a consequence of an affluent society. Our grocery stores are awash in food. Western societies don't have to toil to grow, raise food. All kinds, of foods, easy to prepare and serve foods. And there's the recreational eating: the ballpark; a football or soccer stadium; a hockey rink; festivals; parties; graduations; weddings; birthdays; anniversaries; etc., etc., etc. Yes, me, too. I'm little different from others.

It's what we eat and what is contained in the foods we eat, that is critical to overall health, which includes maintenance and repair of the body, its organs, tissues, and cells, or our undoing. In western countries such as the United States, there is a problem with overweight, even obesity according to government sources.[2] Allegedly some 78.6 million Americans are obese, one third of the US population. Furthermore, obesity is claimed to cost the public some $147 billion in 2008 dollars. Medical conditions attributed to obesity include heart disease and other cardiovascular problems, stroke, Type II diabetes, and certain types of cancers. Furthermore, obesity statistically arises more so among those of middle age (40-59 years old, 40%), while it is

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less problematic among the young (20-39 years old, 30%), or the elderly (over 60 years old, 35%). Additionally, obesity is highest among non-Hispanic black citizens (48%), then Hispanics (43%), then non-Hispanic whites (33%), and bringing up the end, non-Hispanic Asians (11%).

It is not the purpose or intent of this treatise to "point the finger" or find fault with anyone who battles waistline issues. Rather, it is the intent to educate and arm the individual on the salient points about human metabolism and nutrition and how certain food molecules are processed, and do so in a manner that is understandable, informative and most importantly, useful. Much of what we do dietarily speaking is a result of ignorance– not knowing, certainly not understanding, what and why it happens, in some cases anyway.

Metabolism is a term used in biology and chemistry to encompass a range of biochemical reactions occurring in cells and/or whole organisms (human body) that make use of food molecules to build body molecules (muscle, blood, hair, etc.) and to produce energy. The sum total of chemic al reactions that occur to produce energy are termed *catabolism*, while those that produce body mass components (muscle, hair, hemoglobin, body fat, etc.) are termed *anabolism*. These two processes occur simultaneously, though *anabolism* is generally energy dependent, meaning, it requires energy produced from *catabolic* processes to fuel the *anabolic* processes to happen. If you run or jog, you build muscle. But building your leg muscles requires protein intake from your diet to provide the amino acids needed to build your muscle, and the energy is provided by the carbohydrates also in your diet.

Each person has a rest *metabolism*, a minimum rate at which their metabolic reactions occur while completely at rest, while awake, and at 20°C (78°F). This basic metabolic rate is called the *basal metabolic rate*.[3]

A BASIC LAW of CHEMISTRY & PHYSICS versus DIETING

The word *matter* is a term that means the material of which all things are made. In high school you learned about *atoms* and these are matter. But atoms combine to make *molecules* of substances we encounter each day in our lives such as water, metal alloys, and food components such as starch, proteins, fats, and carbohydrates. As it pertains to living organisms such as a bacterium, your pet dog or cat, or you, your body, an important applicable law of chemistry is the *Law of Conservation of Matter*. This law has a direct bearing on dieting. The law states in so many words, *that matter cannot be created or destroyed through ordinary chemical processes*.[4] Dieting practices comply with this law. If you take in more calories than your body needs for a day, the excess will be stored most likely as body fat. If you take in fewer calories than your body needs for a day, it will most likely make up the decreased calories needed by accessing and burning body fat. For an organism to gain *mass*[5] (*weight*), it must ingest matter (food stuffs) in excess of its metabolic needs. The adage: I just have to look at that slice of pie and I gain weight is totally false. For one to gain weight from the slice of pie, it must first go past your teeth.

THE DIETETIC CALORIE

There is a significant push in society to label foods with among other information, their caloric content. You undoubtedly have seen these listings on labels as for example: serving size

one eight slice pie, Calories: 330. There are two kinds of calorie measures– one formerly used by scientists (who now use the *joule*), and one used by dietitians. The scientific or *thermodynamic calorie* is spelled with a small "c", while the *dietetic Calorie* is spelled with a capital "C". The *dietetic Calorie* is actually 1000 times larger than the *thermodynamic calorie*. So, that one eighth pie slice that claims 330 *Calories* is actually 330,000 *thermodynamic calories*. And since each *thermodynamic calorie* is 4.184 *joules*, that pie slice comes in or should I say goes down (the throat) as 1,381,000 joules. That's a lot of calories. However, you label it!

If we consider a 200 lb male and ask, how much water could his daily caloric intake, to maintain his body weight, bring to a boil from room temperature (25°C)? Such a calculation would reveal that if all his caloric intake were actually converted to heat, it would raise the temperature of almost one US gallon of water from 25°C to the boiling point of water (100°C).[6]

DETERMINING DAILY CALORIC NEED

A good starting point for assessing your dietary intake is to first know just what is your daily caloric intake need. There are a number of equations that can be used to determine daily caloric need, but they are equations, and one has to plug existing weight, age, height, etc. into them, and it's a mess to do. There is a simple way, not perfect, but workable. Men can take their current weight and multiply it by 11. Women can similarly take their current weight and multiply by 10. So, if you are a male and weigh in at 200 lbs, your daily caloric intake to maintain that 200 lbs is 11 times that weight or 2200 Calories. For a woman weighing in at 160 lbs, her daily caloric intake to maintain that weight is ten times that weight, or 1600 Calories.

Let's employ an example of gain and loss that is basic and understandable even in a small simple equation- your checking account. Here's the equation I'll use:

$$B\$ = D\$ - W\$$$

where B$ is the balance in dollars, D$ is the deposits in dollars and W$ is the withdrawals in dollars, the dollar value of checks written to creditors. Clearly if you can reduce W$, while maintaining the deposits D$, your balance B$ will increase. But if you start writing a bunch of checks W$ without increasing D$, your balance B$ will decrease. A similarly simple equation can be used for body weight.

One's body weight is a function of caloric intake minus caloric burn and the basal metabolic burn. By caloric burn I mean calories you burn from physical activity for your current weight. I offer the simple equation:

$$W = Ci - Cb - Mb$$

Where W = body weight, Ci is caloric intake, Cb is caloric burn and Mb is your basal metabolic caloric consumption. Clearly if Cb is zero and Ci is greater than Mb, you will gain weight. On the other hand, if Ci is less than both Cb and Mb combined, you will lose weight. If Ci is equal to the sum of Cb and Mb, your weight will in principle remain static.

DIETING– THE DON'TS

I think it is reasonable to say that we Americans tend to be somewhat impatient. We want it now. We want it done now. Dieting seems to suffer from this impatience also. We want to lose the weight now. Well, one does not necessarily put weight on literally over night, and one certainly will not lose all the weight literally over night. But herein is the first problem confronting us, a psychological feature to weight loss.

Think for a moment. Think of any occasion in your life where "losing" anything was a good thing to happen? We have been conditioned throughout our lives to regard loss as bad. From the mundane of losing the car keys, to losing money, or losing freedom, to the more tragic of losing a loved one or your health, none of it is a good thing. Yet now, with dieting, "losing" weight is supposed to be good. The brain says NO! Losing weight is not good. To the brain, weight loss is a "red flag." Something is wrong. There are a host of hormones that come into play with regards to metabolism, and certainly as well in weight loss, and especially "precipitous" weight loss, which all too often, people attempt to do at a drastic and unsustainable level. The brain reacts. A host of signals are sent out. The "hunger pangs" are a clear signal that the brain is well monitoring your body and "finds" this state of affairs inadvisable. It is prodding you to eat or increase your caloric intake. To reduce the difficulty of "losing" weight, one must "outsmart" the brain for any diet plan to be effective, to work, and not become a daily exercise in self-torture from the hunger pangs.

Another issue with dieting is the propensity of many people to weigh themselves nearly every day. This borders on psychological terrorism of oneself. Weight will fluctuate on a day to day basis. Some days you are more active than others, other days you didn't eat as much as you normally may do, etc.

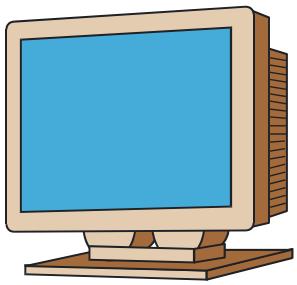
Another matter concerns our own habits. We have become conditioned to doing what we want in our earlier years, but as we age, and often find physical activity decreasing or limitations imposed upon us, some of our youthful habits, such as eating what we want and when we want, and all too often, too much of what we like, we tend to continue doing so. Holidays and other special occasions certainly contribute to this. It is hard to break a lifetime of habits. But like caloric intake, such habits may not be easily altered or broken. It takes time, a methodical approach, and determination. You won't discard a life's worth of habits overnight anymore than you acquired those habits overnight. You may find it useful to pick a habit and focus on it, consciously reducing its frequency over time. In other words, cultivate a new habit. For most of us, "going cold turkey" as the saying goes, is just this side of impossible. Break it in, but do so with determination and as reasonably quickly as you can actually sustain successfully limiting the habit itself while redirecting to a new habit.

And along this line, is the issue of some diets of decades past advocating cutting certain foods out. Not a good idea. Especially carbohydrates and fats any more than you should cut out protein from your diet. However, you can reduce how much carbohydrate or fat you ingest each day.

DIETING– THE DOS

Clearly if a person has some significant medical issues, that person should discuss their condition with their physician as to caloric intake reduction levels, as well as what kind of exercise is OK for their condition. Assuming that there are no underlying cardiovascular, respiratory, or orthopedic, etc. conditions imposing limitations on the person, the following is an approach that should work reasonably well. I say should, if it is followed without "cheating." [As it pertains to dieting, we all tend to "cheat" a little. Once in a great while is not necessarily a problem, but if it is daily, you are defeating yourself daily.]

In any diet plan, the physicians and dietitians strongly advise an exercise program. They urge at least a daily 30 minute physical activity such as walking, jogging, bicycle riding, etc. And if you are doing some kind of exercise activity for at least 30 minutes a day, and actually working your muscles and body, and controlling caloric intake, you will be replacing body fat with muscle. Muscle is twice as dense as fat. This means that as you burn off body fat, you are replacing some of it with muscle. Thus, your weight may actually show a slight increase over time during periods of fat loss, and your weight may show a stabilization or slight increase. So weighing yourself each day is not a good idea, and its not a good measure of success. Now, if you are significantly over weight, yes, for the short term, a reasonable diet control will show a generally steady weight loss. But as that really excessive body fat weight is lost, and muscle is built from exercise, the rate of weight loss from fat itself, will decrease as your activity and body weight approach the "new, lower" body weight for the caloric intake and caloric burn levels you are currently at.



A drastic cut back in caloric intake is a no success approach. A better approach is to cut back slightly. Determine your current daily static caloric need for your current weight, and reduce that intake by say 5%.[7] For our 200 lb male that is a reduction of 100 Calories in nice round numbers. For our female it is 80 Calories. Does this mean I have to know the caloric content of each portion of carbohydrate, meat, fat dish? Well, yes, how else can you adjust your daily caloric intake if you don't know how many calories each item serving you ingest has? However, it is only a "bother" at the beginning. As you determine the caloric content of that quarter pound hamburger, that half cup of potatoes, the three teaspoons of your favorite salad dressing, etc., you know that data for subsequent meal inclusions of those foods. BUT, you must know the sum total of calories on your plate for each meal for each day, and if you really want to lose some weight, you must reduce your total daily caloric intake BELOW your current weight calories value (calculated as shown above).

Does this mean that you can eat whatever you want? Yes and no. Any dietary restrictions that your physician has advised you follow should not be ignored. But weight gain is not a function so much of anyone thing you eat, but rather how much of it you eat in one day in addition to regular meals consumption– meaning the snacking through the day, or that fast food greasy spoon loaded hamburger and those large double order fries. [Those kind of foods in one sitting can easily exceed your total allowable caloric intake for the entire day!]

It is useful to keep the weight equation above in mind. It says your weight gain or loss is a function of everything you ingest throughout the day, minus your basal metabolic burn minus any

physical exertions you do. If that caloric intake exceeds your basic metabolic rate and the exertion caloric burn, then you not only can expect to gain weight, it should not be a surprise to do so as seen on the bathroom scale. If you really like that chocolate ice cream with the chocolate syrup on it, and your physician hasn't advised to you leave it alone completely, you may have some, but be reasonable about the portion size and calories of it you take in. It and the calories of everything else you eat that day must be less than your weight times 11 (if male) or 10 (if female).

In conjunction with that reduction in caloric intake, increase your physical activity. Do something that is permissible for you and works your muscles– walk, jog, ride a bicycle, or if possible for you, cut the grass with a non-riding lawn mower as examples. Table 1 lists several activities and the caloric burn for that activity per minutes duration indicated.[8]

Don't weigh yourself daily. At the most, weigh yourself once a week. Pick a convenient day, perhaps in the morning before any breakfast. But a better measure would be to use a tailor's tape measure to measure yourself around say your waist, or your thighs, some place where you know weight accumulates. This is better as you lose body fat, the girth of that location should show a decreasing overall length on that tailor's tape measure. And, and this is equally important from a psychological viewpoint, don't expect or insist on dramatic decrease changes. It isn't so much how much weight you lose in a week or month, or how smaller the girth measurement is each week or each month. It is that it IS less, and it remains off, and you don't feel like your starving yourself during the process!

PRINCIPAL DIETARY ISSUES

Over the past few or several decades, there have been a number of diet programs that have touted their ability to help you lose weight. Some have even advanced the notion that you should cut out carbohydrates or fat, or whatever. I have no intention of going into them as from the start, most violate serious principles of biochemistry and are potentially dangerous to some people with serious medical conditions, though perhaps fortunately, most people don't stick to any such diets, perhaps dropping off of them before any real harm can set in, by themselves or at a physician's directive. But there are a few facts at this point that should be borne in mind at all times when embarking on any diet program.

First, it is true that carbohydrates (in excess intake) are converted to body fat (chemically classified as *triacylglycerols or triglycerides*). Biochemically this is because humans have evolved to use carbohydrates as the first principal energy source, and they are so plentiful throughout the "food environment" (corn, rice, potatoes, etc.). Additionally, the energy possessed by carbohydrates (think in terms of glucose here) is considerable for such a small molecule, and that energy if "consumed" but not needed is not discarded. The body cannot store much glucose (other than in liver or muscle as *glycogen*– animal starch), so it converts the excess, unused glucose to fatty acids (*long carbon chain carboxylic acids*) and then attaches those to *glycerol* to become the body fat that is deposited to fat cells (*adipose tissue*) and stored for a "rainy day", meaning when you need energy and carbohydrate intake is below sustainable levels.

Second, the avoidance of fat is an iffy issue. There are what are called *essential fatty*

acids, fatty acids that the human body cannot produce through any human anabolic processes, but are absolutely necessary for body cells. The brain is one organ that has a need for certain essential fatty acids. Historically, the development of the human brain has been at least loosely tied to the ingestion of meat and animal fat sources, resulting in an increase in brain size from some 450 cm^3 of the *Australopithecinae* to about 1350 cm^3 of today's *Homo sapiens* over some 3.5 million years.[9] So cutting fats out entirely, though on the one hand most likely impossible, on the other hand, may be nutritionally harmful. Having said that, ingestion of excess fats is not a good idea any more than ingesting copious quantities of carbohydrates is a good idea. BALANCE. That's the watch word for any diet. Fats are one of the "flavoring" components of various foods. A hamburger tastes so good because of the fats in it, that during cooking, are chemical altered giving the flavor that attracts us. One of the problems with low fat foods is that with reduced fat, reduce flavor automatically follows. One way processed foods manufacturers get around this is to add sugar, a carbohydrate. Sweetness also attracts us. The "sweet tooth" actually isn't a tooth in our mouth. It's the brain that is the sweet tooth." Its primary and preferred energy source is glucose, a component of sugar.

Then there is the biochemistry of the carbohydrates versus fats issue. Let's examine this below as a result of other important considerations that arise as well.

THE HIERARCHY of BIOCHEMICALS of FOODS

Foods fall into four major classes of biochemical substances. Those four classes are (a) *carbohydrates*, (b) *lipids* (including fats), (c) *proteins* (including amino acids), (d) *nucleic acids* (DNA and RNA).[10] Of these four classes the first two are of considerable importance in catabolic reactions performed by cells to produce energy. Carbohydrates come in several forms, but for humans the two most common and important forms are *starches* and *sucrose* (table sugar). While half of a table sugar molecule is *glucose* (a simple *aldohexose monosaccharide*), the other half being *fructose* (a simple *ketohexose monosaccharide*), starch is a branched polymer (generally looks like a tree) of glucose. Starches are the major component of food crops such as rice, corn, and potatoes. In the plant world another major polymeric carbohydrate also is prominent. It is *cellulose*. There are significant differences in how the glucose molecules are joined in *starches* compared to *cellulose*, but *cellulose* unlike *starches* has no branches, it is a linear (like a string) only polymer molecule.[11] The long stingy strands of celery offer a large-scale hint of what the cellulose molecule is like.

Humans have evolved to make use of carbohydrates (glucose) as a principal energy source. If carbohydrates are absent or insufficient, fats are the second fall back principal energy source. The presence or absence of glucose in the diet dictates just what of the biochemical reactions (called *pathways*) will or will not operate at full effect. This has significant impact on general health, and even in certain cases of pathology such as diabetes (types I or II). So how is it determined to use what you eat, and what happens to it all?

ROLE of PANCREATIC HORMONES and CARBOHYDRATES

Usually, any meal humans ingest contains carbohydrates, proteins (meats, fish, beans, etc.), and fats as the major components of the matter ingested. Clearly, they are not necessarily

balanced in portions, or daily recommended amounts of each, etc. The carbohydrates as noted above consist mainly of glucose (starches) and as a result of digestive processes starting in the mouth (chewing, α-*amylase*), the starches are broken down until in the small intestines, glucose molecules are released in copious quantities. The glucose is absorbed into the blood stream and due in part to brain hormones responding to the fact, the *pancreas* secretes the protein hormone *insulin*.

Insulin is a hormone that basically signals a fed state, meaning it tells the liver tissue cells you have eaten. Now here's the fine print on this. The "fed state" really only means you have ingested a glucose source (*cellulose* will not trigger release of insulin, so it is not a source of glucose for humans.[12] If you had ingested a meal of only rice, the same response by the pancreas would be elicited. The inability of the pancreas to synthesize and release insulin in the presence of high blood glucose levels beginning at an early age such as adolescence is the basis for diabetes Type I or juvenile onset diabetes. Insulin has a number of significant effects on cells especially liver. [The human liver is a remarkable organ with a number of critical biochemical jobs to perform on behalf of the human body. More of this later.] Insulin has the following effects:

1. signals a fed state (only if carbohydrate specifically is ingested)

2. increases cell permeability for glucose absorption into cells

3. increases cell permeability for amino acid absorption into cells

4. favors the process called *glycolysis* (carbohydrate, glucose burning), which is the biochemical processing machinery (*pathway*) for catabolically metabolizing glucose leading to the production of energy in the form of *ATP* (Figure 1 shows an abbreviated glycolytic pathway for those interested in the process.)

5. disfavors fatty acid utilization (called β-*oxidation*, burning fat)

6. suppresses (muscle) protein breakdown (called *proteolysis*, breakdown of body muscle; digestion of dietary proteins is governed by a different set of enzymes and hormonal signals)

7. disfavors glucose synthesis (*gluconeogenesis*). [In absence of glucose intake, many other biomolecules resulting from metabolism can be converted to glucose. Insulin suppresses this process as insulin secretion is a signal that blood glucose is high from ingestion.]

8. favors fatty acid synthesis from excess, unused glucose (this is the carbohydrate becomes fat point)

9. favors synthesis of liver (*hepatic*) glycogen (*glycogenesis*) from excess, unneeded glucose intake (from carbohydrate sources such as starch)

10. counters the effects of the other pancreatic protein hormone *glucagon*

Glucagon[13] has the following effects:

1. signals energy (intake) deficient state (in control in absence of carbohydrate ingestion or blood glucose levels are below normal)

2. allows *proteolysis*

3. disfavors *glycolysis*

4. favors β-*oxidation* of fatty acids from breakdown of body fat (*triacylgycerols*) from adipose (fat) tissue; becomes the major source of fuel molecules to produce the energy molecule ATP under low glucose ingestion

5. favors *gluconeogenesis* (glucose synthesis) from certain amino acids (resulting from *proteolysis*[14]) and other simple precursors

6. favors breakdown of liver glycogen (*glycogenolysis*) to release liver glycogen glucose into the blood stream

It is the ratio of *insulin/glucagon* that determines what will happen metabolically with carbohydrate ingestion. If the ratio is high, insulin is in charge so to speak and the process of glycolysis is in full gear. If the ratio is low, *glucagon* is in charge and *glycolysis* is disfavored, but metabolism of fats is favored (even *amino acids* as well).[15]

ROLE of LIVER in ALL of THIS

No one organ is supremely important or critical as the body is an integrated system, all organs and tissues performing their own and generally unique duties, all of which are absolutely necessary for the maintenance, repair and sustaining of the whole. But the liver has a number of important functions that are in of themselves critical to overall health and in the event of liver disease or even failure, the consequences are obvious and lethal if uncorrectable medically speaking. Jaundice is an indiction that something is not right in the liver.

The liver performs several functions:

1. It is the site of detoxification of harmful chemical substances, and even breakdown products of some biomolecules no longer needed by the body. All medications end up in the liver for biochemical processing rendering them less toxic and more soluble for excretion in urine. This is not fool-proof. Some substances may actually be processed to a more harmful byproduct, or so much of a substance may be ingested that it overwhelms the liver's capacity to process all of it. An example of these issues is the active ingredient in Tylenol, *acetaminophen*. Another example is *cyanide*. Some foods have small amounts of cyanide in them which is processed by the liver, producing *thiocyanate*, a cyanide derivative that is about 300 times less poisonous than cyanide.[16] However, the liver cannot detoxify large amounts of cyanide.

Pathogenic chemical substances also are processed in the liver for detoxification. An example is the *pyrolytic* (burning) byproducts of organic material such as *benzo[a]pyrene*, a *polyaromatic hydrocarbon* and known chemical carcinogen.[17] However in this example the detoxification byproduct is *benzo[a]pyrene diol epoxide*, the actual carcinogen, which means that sometimes the liver converts a substance to something even more dangerous than the substance itself.[18] Another example is the toxin *aflatoxin B1* produced by the action of the microbe *Aspergillus flavus* on grains and peanuts.[19]

2. It has the sole responsibility to maintain blood glucose levels for the brain. This means it either removes excess glucose (above normal blood levels of about 80 mg/dL) from blood, storing it as glycogen, or dumping glucose into blood that is below normal levels to bring the glucose level up to normal levels, drawing on its *glycogen* reserve as the source of the glucose.

3. It is the principal and vastly major site of *gluconeogenesis*, glucose synthesis from such molecules as *lactic acid* resulting from muscular contractions during *anaerobic glycolysis*. This biologically relieves other organs and tissues of the very expensive energy cost of synthesizing a glucose molecule from *glucogenic* precursors (such as *lactic acid* [20]) found in blood. [The energy required for this can come from β-*oxidation* of fatty acids.]

4. It is the site of β-*oxidation* of fatty catabolism during decreased or absent carbohydrate intake and fatty acid anabolism from excess glucose intake.

5. It is the source of what are called *ketone bodies*, acidic molecules resulting from rampant β-*oxidation* of fatty acids from body fat.

HEPATIC RESPONSE to NON-FED STATE

How does the liver participate in glucose metabolism in the non-fed state (liver responds to *glucagon* binding)? Since no carbohydrate was ingested under the non-fed state, *glycolysis* is minimally active and cannot metabolize glucose that is not available to make ATP energy. Thus, the body switches to utilization of fatty acids from body fat stores (*triglycerides*). The fatty acids are metabolized in an *organelle* called a *mitochondrion* (plural: *mitochondria*) in a process or *pathway* called the *Tricarboxylic Acid Cycle (TCA)* Figure 2 illustrates an abbreviated version for those interested in the process*)* to ultimately produce the energy rich molecule ATP. This entails an intermediate molecule (*acetyl-CoA*) being produced that rises very high in concentration and much of it is converted to another class of energy producing molecules called *ketone bodies*. Figure 3 illustrates an abbreviated ketone body synthesis pathway from acetyl-CoA for those interested in the process. These molecules are acids, are dumped into blood and circulated throughout the body for absorption by other cells of other tissues and organs since glucose is minimally available and not sufficient to provide energy. This process happens if you haven't eaten for a day, or longer, in starvation, or in diabetes.

In the case of forced starvation, not eating anything at all for several days, the *ketone body* levels in blood can become rather high, and as acids, they lower the blood's *pH* (a measure of acid concentration). Since acids can *denature* proteins (change their shape and functional

abilities), and *hemoglobin* is a protein which carries oxygen, the *hemoglobin*'s ability to bind and carry oxygen is reduced, thus reducing the level of oxygen in blood. The brain monitors oxygen levels of blood via the *carotid artery* in the neck by "measuring" the *pH* of the blood. Since the brain and heart are the two organs that have the greatest single need for oxygen and are most susceptible to decreased levels of oxygen in blood, if oxygen levels due to the *ketone bodies* level in blood is very low, a condition known as *ketoacidosis* results. Since there is not enough oxygen in blood for brain, heart and muscular activity all simultaneously, something has to give to make the oxygen level in blood "stretch" out for organ and tissue needs. One outcome is that a person under *ketoacidosis* may pass out, faint, if too active for the level of oxygen present. *Ketoacidosis* can be a serious resulting condition, in the extreme, lethal.

[As an instructor of college chemistry, I have actually had over my career, two students pass out in lecture class, completely collapsing in their seat like a rag doll, and later learned (after calling an ambulance) that the student in question hasn't eaten for several days, for whatever reason. A diabetic who is on insulin treatment, but isn't taking the insulin, or monitoring their blood glucose levels, can also pass out from *ketoacidosis*, but in the case of a Type I diabetic, the issue is more serious as going into a coma is a real potential threat owing to the greatly more complicated ramifications of Type I diabetes.[21]]

In prolonged fasting or starvation state cases, eventually liver glycogen is exhausted, and if several weeks to a few months of poor or little dietary intake is the case, body fat reserves become diminished or essentially depleted. Under such a case, the only remaining energy source is the body's *skeletal muscle mass*. In such a case, the body in its scramble for energy breaks down body muscle (*proteolysis*) releasing the amino acids of those proteolytically hydrolyzed proteins. The amino acids are *deaminated* (remove the α-amino group). The liver converts the amino group to *urea*, and processes the remaining carbon structure (generically called *ketoacids*). Two things happen with those *deaminated amino acid* carbon structures. Some (called *glucogenic*) can be converted to glucose, while others (called *ketogenic*) are converted to TCA intermediates. It is the breakdown of body muscle attending prolonged starvation (as seen in WWII documentation of concentration camp inmates), or in the case of chronically untreated Type I diabetes, that leads to severe weight loss and the skeletal, emaciated appearance of such afflicted individuals. This process is the most significant visually demonstrated proof of the human body digesting or "eating" itself in its search for energy, that is not being ingested in the case of starvation, or absence of insulin control in Type I diabetes, untreated.

Even under non-extreme dietary intake reduction, where less carbohydrate than is daily required, some proteolysis will occur. It is just reduced in extent, and in very low or absent carbohydrate intake, a high dietary protein intake makes maintaining or building muscle problematic given that the hormonal signals (reduced or absent *insulin*, high *glucagon* presence) are saying you are not fed.

CRASH DIETING

I will define a crash diet as one in which a person goes several days without eating. This is different from fasting in that generally medically ordered fasting is an overnight process preceding a gastrointestinal procedure, say don't eat anything after midnight, and no breakfast the

following morning, or is a one day observance, perhaps for religious reasons. A crash diet is one in which a person eats nothing for two or three days, or in the extreme, longer. For a person who is healthy, has no medical conditions, a day or two without food, not necessarily voluntary, is generally not going to present any serious problems, other than, certainly, uncomfortable and chronic hunger pangs. This is the brain saying, EAT.

The problem with crash diets is that all bets are off, meaning for a given individual it is difficult to predict just what the outcome may be, not knowing their medical history. But as discussed above, biochemically speaking, certain things WILL happen. Without recounting the details above again here, the sequence of biochemical outcomes are:

1. the pancreatic protein hormone *glucagon* is in control of metabolism

2. liver *glycogen* will be essentially exhausted, blood glucose levels will decrease over time[22]

3. to provide energy, liver is metabolizing body fat fatty acids via β-*oxidation*

4. the metabolism of fatty acids from adipose fat stores, leads the liver to produce *ketone bodies* (those acidic molecules produced from *acetyl-CoA*)

5. those *ketone bodies* are dumped into the blood stream by liver to try and provide the body with energy

6. if prolonged crash dieting (starvation state), the level of *ketone bodies* in blood, coupled with muscle *lactic acid* production, and other acidic molecules in blood, can become high enough to reduce blood *pH* enough to decrease oxygen binding by blood's hemoglobin of the red blood cells. This can lead to *ketoacidosis*, which can affect one's state of consciousness, leading to dizziness, fainting, etc.

7. As *insulin* is not active now, absorption by cells of any glucose produced by the liver via *gluconeogenesis* is less effective

8. proteolysis, breakdown of body muscle will occur at a greater level, producing amino acids, some of which will be utilized in *gluconeogenesis*

9. this mimics not only starvation, but aspects of diabetes as well

10. if prolonged, as in clear cases of starvation, the body is burning its own mass in the drive to find energy.

11. over extended periods of time (such as a hunger strike), this can affect the cardiovascular system, brain and other organs such as kidneys.

Even in short periods of time, crash diets are not helpful, even harmful depending on the

individual's medical condition. Not a good diet option at all.

HEPATIC RESPONSE to FED STATE

The fed state is indicated by increased insulin secretion from the pancreas in response to carbohydrate intake, resulting in the increase of blood glucose levels. The result, from the listing above, is that insulin prompts cells to absorb glucose from blood better. It also increases the improved cellular absorption of amino acids resulting from the digestion of dietary protein intake, releasing the amino acids into the small intestines, which absorbs those amino acids into the blood stream.

The hepatic cells take the absorbed glucose and use it to replenish any *glycogen* stores. The same is true of muscle cells that had been engaged in active muscular contractions. Additionally, if the carbohydrate intake is greater than what is minimally required for a day, the liver will take the unusable glucose excess and convert it to fatty acids. This is because in running glucose through its glycolysis, it produces the aerobic end product *pyruvic acid*, which normally passes into the mitochondria to enter the *TCA cycle*. Large amounts of the TCA intermediate *citric acid* is produced, but so much of it, that a lot of the citric acid leaves (through membrane transport proteins) the mitochondria to enter the cytosol where *glycolysis* operates, but is used to make the fatty acids (it's actually only one, called *palmitic acid*). This is the connection that is the basis of the saying: carbohydrate equals fat. The produced fatty acids from excess carbohydrate ingestion travel to adipose tissue where they become the *triacylglycerols* or *triglycerides*, body fat. This is the problem with so many foods high in carbohydrate (starch or table sugar), or with ingesting large excess amounts of carbohydrates on a daily basis (especially with no physical muscular exertions to burn the resulting excess blood glucose off).

Muscle cells also absorb glucose from the blood, and they too, replenish their *glycogen* stores which serve as a source of glucose for energy for active muscular contraction during *anaerobic glycolysis*. During exercise, muscles burn glucose. At rest, no contractions, the muscles use fatty acids from adipose tissue as the energy source. This is the basis for the saying: muscles burn fat,[23] meaning the more muscle mass you have, the greater quantity of fat is burned by the muscles, since they generally are at "rest", most of the day (unless you do "heavy lifting" or physical work activity for a living). Additionally, as you replace body fat with muscle, you will increase the rate at which you remove or burn body fat. (You won't be able to notice this since it is a slow and imperceptible process as far as real time is concerned.)

The *insulin* also impedes *proteolysis*. Thus, since carbohydrate ingestion results in glucose in the blood causing the secretion of *insulin*, the body has no need for burning fats through β-*oxidation* or mobilizing the body's skeletal muscle as a source of *glucogenic* amino acids. This "conserves" existing body muscle, and allows for the replacement or building of new muscle tissue, all powered by the energy produced from the glucose residing in the carbohydrate.

HEPATIC RESPONSE to DIABETES STATE

The effects discussed above about carbohydrate deficient diets follow in diabetes also. However, Type I diabetes especially harbors much more serious consequences than simple

carbohydrate deficient biochemical processing in the body's search for energy in its case. A host of secondary complications arise such as with the eyes, kidney, heart, and neurological problems, and in the case of neurological issues, extremity nerve sensitivity and in some cases nerve insensitivity tissue necrosis, that can lead to serious injuries the untreated Type I diabetic may incur which he or she may not feel or know has happened and subsequently suffer in the extreme, gangrene, if not treated. Amputations of extremities (such as toes, foot) were once a not so uncommon outcome in untreated Type I diabetes.

ENERGY YIELD of GLUCOSE versus FATTY ACIDS

As noted before, *ATP* is the energy molecule (or as some biology books say, the currency) of life. Food molecules are metabolized to ultimately extract the energy within them in order to use that energy to make *ATP*.[24] How much *ATP* can a glucose molecule or a fatty acid molecule make?

In the case of glucose following the *aerobic glycolytic* route including the passage of two *pyruvic acid* molecules into the mitochondrion, a cell can ultimately produce 36 to 38 *ATP* molecules for each glucose molecule so processed, depending on the tissue cell in question.

The *ATP* yield from a fatty acid from body fat depends on how many carbons long the fatty acid is. As an example, if a *palmitic acid* fatty acid molecule (16 carbons long) is metabolized via β-*oxidation* within the mitochondrion, the yield is 129 ATP molecules.

It is clear that a *palmitic acid* molecule yields about 3.5 times as much ATP than a single glucose molecule. For every two more carbons in the chain length of a fatty acid longer than *palmitic acid*, the yield in *ATP* increases by about 17 *ATP*. So why do we use glucose (carbohydrate) as the primary energy source rather than fat (fatty acids)? There are a number of reasons concerning limitations in storing glucose, its processing, etc. within cells. But perhaps another reason more understandable and tied to evolution is the facts surrounding carbohydrates versus fat in nature. The environment's plants are mostly carbohydrate (*cellulose*) though what we grow for food contains large stores of starch (corn, rise, potatoes) and sucrose (sugar cane, sugar beets). As you drive throughout the farm belts of the US, you see carbohydrate crops. When was the last time you saw a field planted in fat? Fat is an animal product, not a plant product, with a few exceptions such as peanuts. Carbohydrate is simply so much more prevalent and available.

VITAMINS

The term *vitamin* has an interesting history. Way back in the very early 1900s, a group of missionaries were serving in China and one of their goals was to improve the nutrition of the Chinese people in their region of activity. Rice was the staple food commodity, and then as today, its processing removed the outer "husk" covering. That reject was fed to chickens, and the processed rice fed to the people. Well, the people become ill from what we know today as a vitamin deficiency, while the chickens were "healthy as a horse". A researcher determined that there was an *amine* compound in the husks that the chickens ate, while absent in the rise grains themselves that people ate. This sparked two outcomes. One, it resulted in the *amine* compound

necessary in the human diet to be referred to as a "vital amine", and two, it stimulated research into a search for other such necessary "vital factors" or "vital amines" also necessary for humans to ingest in the diet.

But that research in discovering those compounds, also noted that not all of those alleged "vital factors" were *amines*. So the term "vital amine" was contracted to *vitamin*.

Today, everyone is cognizant of the need and importance of vitamins in the diet. What they likely don't know is that we need these compounds for two reasons. One, we cannot synthesize these compounds ourselves, so we must, yes, kill and eat some other organism (bacterium, plant, or animal) to acquire them, and the so called *vitamins* are the precursors (building blocks) for many compounds they are used to make in our bodies, these compounds called *coenzymes*. They are called *coenzymes* because various *enzymes* require a *coenzyme* molecule for their beneficial biological activity. Without the *coenzyme*, the *enzyme* is biologically inactive, useless. Of course, *vitamins* are today packaged in pill form, and there is some concern that we may be on the other end of the *vitamin* spectrum, overdosing ourselves with them. In small amounts, *vitamins* are absolutely necessary. But several *vitamins* are themselves potentially injurious or poisonous in nature if taken in "mega-doses". If you are ingesting a balanced diet of various foods, you really shouldn't need to take *vitamin* supplements, unless a physician has directed you to do so for a specific condition he or she is addressing and monitoring so you don't become overdosed.

The point here is that in any diet, arbitrarily cutting out certain foods or food groups is not the sound approach as you may also be cutting out necessary *vitamins* contained in the food you omit consuming. Rather, a balanced diet is the ideal and nature's way. Thus, cutting total, daily caloric intake back to that which is sufficient for maintenance of your preferred body weight (and body mass index if you prefer), rather than cutting out carbohydrates or fats, or whatever your "body weight terror food" is, is the better way to manage your body weight.

Table 2 lists several *vitamins* and *minerals* required daily in the diet. Table 3 lists the FDA recommended daily allowances of several common food components. Table 4 lists recommended amounts of some food components.

RAMIFICATIONS of EXCESSIVELY HIGH CARBOHYDRATE INTAKE

As considered above, excessively high carbohydrate (starches and sugar) intake, which boosts overall daily caloric intake well above minimums to maintain a static body weight, the excess not required for biological purposes, will be converted to body fat. But this isn't the end of the issue. There are other considerations that enter the picture when excess carbohydrate/excess caloric intake is the daily norm and practice. In addition to various degrees of obesity, other complications accrue from the increased body fat synthesis utilizing the excess carbohydrate. Increased levels of the *Low Density Lipoprotein*, LDL, which is rich in fats and *cholesterol* (a lipid class molecule) are ascribed to leading to clogged arteries, *atherosclerosis*. Of course, the onset of *Type II diabetes* also can occur over time.[25] With respect to excess daily carbohydrate and caloric intake there is one biomolecule that figures rather prominently in all of this. It is the metabolically important *acetyl-CoA*.

Acetyl-CoA arises principally in the mitochondrion from the processing of the *glycolytic pyruvic acid* from oxidation of glucose via *glycolysis*. It also arises in "copious" amounts when carbohydrates are lacking and β-*oxidation* of body fat fatty acids in the main source of energy as a result of the pancreatic protein hormone *glucagon* being in charge (*insulin* is very, very low).

As noted earlier, under low or absent carbohydrate intake, the body switches to β-*oxidation* of body fat fatty acids as the source of energy production (ATP) by producing large amounts of *acetyl-CoA*. This is shown to arise in Figure 4. Additionally, as the *acetyl-CoA* is in so high concentration, much of it is shunted to produce the *ketone bodies*.

Figure 5 schematically illustrates the biomolecules leading to the rise of *acetyl-CoA* as well as the biomolecules produced within the human body from *acetyl-CoA*. It is clear that in this context, *acetyl-CoA* is a central biomolecule arising from catabolic processes as well as serving as a precursor in a number of anabolic processes. It is this later case that plays a central role in some of the consequences of excess dietary carbohydrate caloric intake.

In the context of this section, if carbohydrate intake is excessively high, this will lead to large amounts of *acetyl-CoA* produced. As the *acetyl-CoA* leads to synthesis of body fat, lipoprotein transport of lipids in blood requires *cholesterol* for those *lipoproteins*. Thus, high carbohydrate intake also can lead to the synthesis of *cholesterol*.

The issue of *cholesterol* synthesis arises during very high carbohydrate intake. In the case of insufficient or absent carbohydrate intake, β-*oxidation* is running, but this processing also suppresses many anabolic biosynthesis processes, including *cholesterol* synthesis.[26]

The MITOCHONDRION and β-OXIDATION, etc.

Our examination of the metabolism of carbohydrates and fats concludes with the workings within one of the remarkable *organelles* of *eukaryotic* [27] (animal and plant) cells, the *mitochondrion*. This *organelle* has been referred to as the power house of the cell. It is within the *mitochondrion* that the bulk of all energy made in the form of *ATP* occurs.

Regardless if carbohydrate (the glucose) or fatty acids are used to make the required *ATP* energy, the common connection is *acetyl-CoA*. The *mitochondrion* houses not just the *TCA cycle*, but many other critically important *pathways* for energy production, one more being the β-*oxidation pathway*. The fatty acids from adipose tissue are delivered to the liver where they are packaged in a certain way to permit their transport across the *mitochondrial* membrane. Within the *mitochondrion*, they are converted to an analog of the *acetyl-CoA*, a *fatty acyl-CoA*.

The fatty acyl-CoA is broken down through repeated spiraling hydrolysis to release with each turn of the β-*oxidation pathway*, an *acetyl-CoA*, and a few other important products.[28] These *acetyl-CoA* molecules enter the *TCA cycle* and ultimately produce 12 *ATP* for each *acetyl-CoA*. However, so much *acetyl-CoA* results from β-*oxidation*, that not all of it can be utilized. The reason has to do with that sweet tooth organ, the human brain. It likes its glucose, and the liver is responsible for providing glucose however, and whenever it can. As a result, one of the *TCA* intermediates (called *oxaloacetic acid*) is also being used to make glucose. As result, not all

of the *acetyl-CoA* can be run through the *TCA cycle*. The excess, *TCA* unusable, *acetyl-CoA* is then converted to the aforementioned *ketone bodies* within liver cells for transfer to blood to provide them for other cells of the body to absorb them, and convert those *ketone bodies* back to *acetyl-CoA* within their own mitochondria.

The reader may be wondering at this point, if carbohydrate intake is very low or absent, resulting in the metabolism of fatty acids from body fat, leading to the production of large quantities of *acetyl-CoA* within the mitochondrion, then with all that *acetyl-CoA*, why isn't *citric acid* being produced in similarly large quantities and then leading to fatty acid synthesis? The answer is that in liver, with its biochemical responsibility and charge to synthesize glucose for the brain, a *TCA cycle* intermediate noted earlier is drawn off to synthesize the glucose. The liver can't make much, but it does what it can with what it has. This intermediate is the *oxaloacetic acid* that is required also to react with the *acetyl-CoA* to produce the *citric acid* that in high concentrations (as does occur in carbohydrate glucose *catabolism*) would be transported outside of the *mitochondrion* into the *cytosol* where it would be converted to *acetyl-CoA* for fatty acid synthesis. Since the *oxaloacetic acid* is being drawn of in some quantity to be used to make glucose under β-*oxidation* conditions, it can't be used in large amounts to make *citric acid* and run the *TCA cycle* at optimal levels commensurate with the available *acetyl-CoA* produced from the fatty acids breakdown.

And for the reason cited, the excess *acetyl-CoA* finds itself diverted to the production of *ketone bodies* also within the *hepatic mitochondrion*.

SUMMATION

Given our life-time of habits concerning foods we like and ingestion habits, dieting to control weight, lose weight is anything but easy. Doing so by drastic caloric reduction approaches is likely a recipe for failure, as the human brain monitors body weight and precipitous body weight lose is a signal of peril. Cutting out whole food groups such as carbohydrates leads to metabolic processing consequences that mimic several earlier starvation states[29] of the five levels depending upon the duration of the diet effort. Cutting out fats entirely, if even possible, risks removing essential fatty acids required in the human diet.

To avoid the onset of severe, prolonged hunger pangs attending "crash diets", it is much more effective to reduce daily caloric intake just below that which maintains normal or basal body weight. This lessens the degree of decrease in caloric intake, without creating a state of "depravation" that would sustain glucagon control of metabolism with all the adverse processes that would then take place.

Weighing oneself each day is pointless if not psychologically frustrating as body weigh will likely fluctuate from day to day. Weighing oneself once a week at the most is best. Since any diet program, and certainly physicians and dieticians, advocate a daily exercise regimen and under such a daily regimen one can expect to lose body fat b ut gain muscle mass, which is twice as dense as body fat, a better way to monitor body fat weight loss is to measure critical areas of fat storage such as waistline, thighs and such. Even here, though, a weekly measure at best is advisable, as muscle gain from exercise in replacing body fat may not necessarily be as quickly

registered depending upon the level of daily exercise exertion.

Psychologically, focus not so much on loss of weight, but on gain of muscle, or improving trim, anything carrying a more positive connotation to you consciously as well as unconsciously to the brain. Small point perhaps, but success is made in small ways. And, don't expect dramatic changes, certainly not well into your dieting process. You likely took years to gain the weight you seek to lose, and you won't lose it in a day, week, or month. Any crash diet approach may actually prove frustrating as you will be constantly hungry as the brain prods you to eat, and in the extreme, potentially harmful in some ways.

Always remember, you cannot create or destroy body weight mass by "thinking" it. You must eat more calories than you need to gain the body fat weight, and you must eat less calories each day to lose some body fat weight. It is a Law of the Universe, and though we may be able to break human laws, with consequences, we can't break Laws of the Universe. Looking at the slice of cake does not put weight on you. You must eat it and then some to gain the weight.

FIGURES

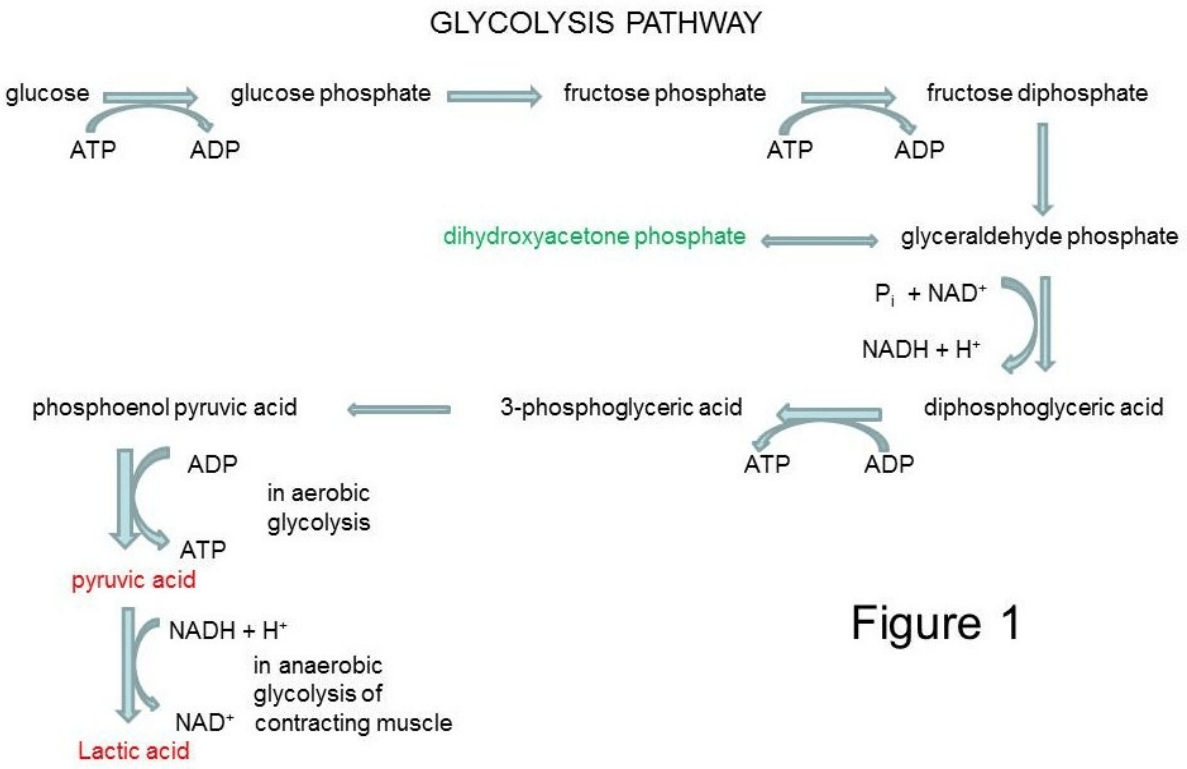


Figure 1

Figure 1: Glycolysis is the principal pathway for oxidizing glucose. The end product for *aerobic glycolysis* (with oxygen present) is *pyruvic acid*. In muscle cells, actively contacting, the *pyruvic acid* is *reduced* to produce *lactic acid* in what is called then, *anaerobic glycolysis* as oxygen is limited. This is so because for glycolysis to continue under low oxygen (mitochondrion is not employed), the *oxidation* of *glyceraldehyde phosphate* requires the use of NAD^+ which can only come from *reducing* the *pyruvic acid* to *lactic acid*, regenerating the needed NAD^+ from *NADH*. In aerobic glycolysis, the pyruvic acid enters the mitochondrion for further processing. Enzymes involved in all of this are not shown.

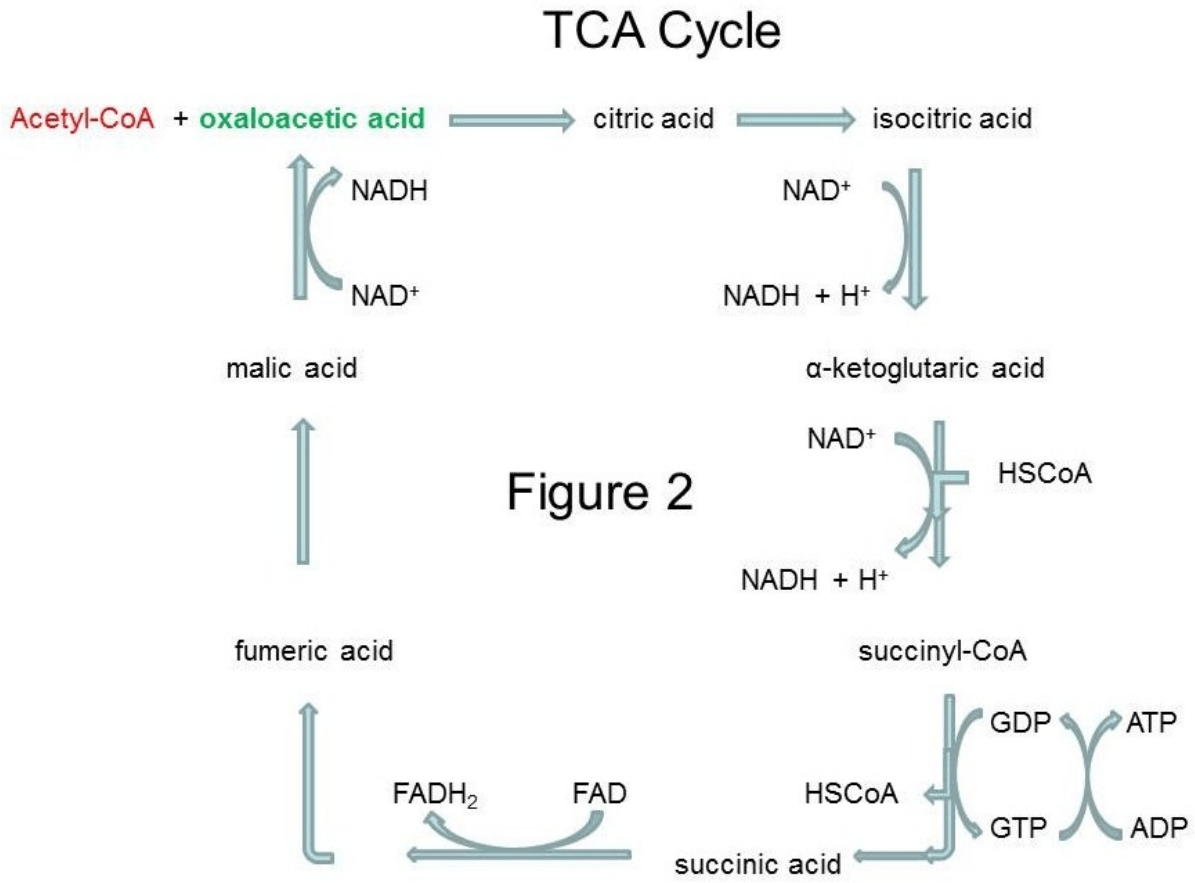


Figure 2

Figure 2: In the *TCA cycle*, *pyruvic acid* is converted to *acetyl-CoA* (not shown in figure). As *fatty acid* β-*oxidation* also produces *acetyl-CoA*, the *acetyl-CoA*, regardless of its precursor source, combines with *oxaloacetic acid* to produce *citric acid* (the name sake of the pathway). Ultimately the pathway returns to the starting point of *oxaloacetic acid* where it combines again with another *acetyl-CoA* to continue the process. What the *TCA cycle* produces is called *reducing power* in the form of *NADH* and $FADH_2$. These molecules enter another important pathway called the *Electron Transport System* (not shown) which move the *electrons* along a chain of proteins to ultimately be passed to oxygen to make water. The hydrogens (called *protons*) are passed out of the mitochondrion, only to reenter through a specific protein *enzyme* called *ATP synthase* which is where all the mitochondrial *ATP* is made. In the lower right of the figure, a *GDP* is converted to a *GTP* which in turn is converted to an *ATP*. This is the only place in the *TCA cycle* where an *ATP* is made directly.

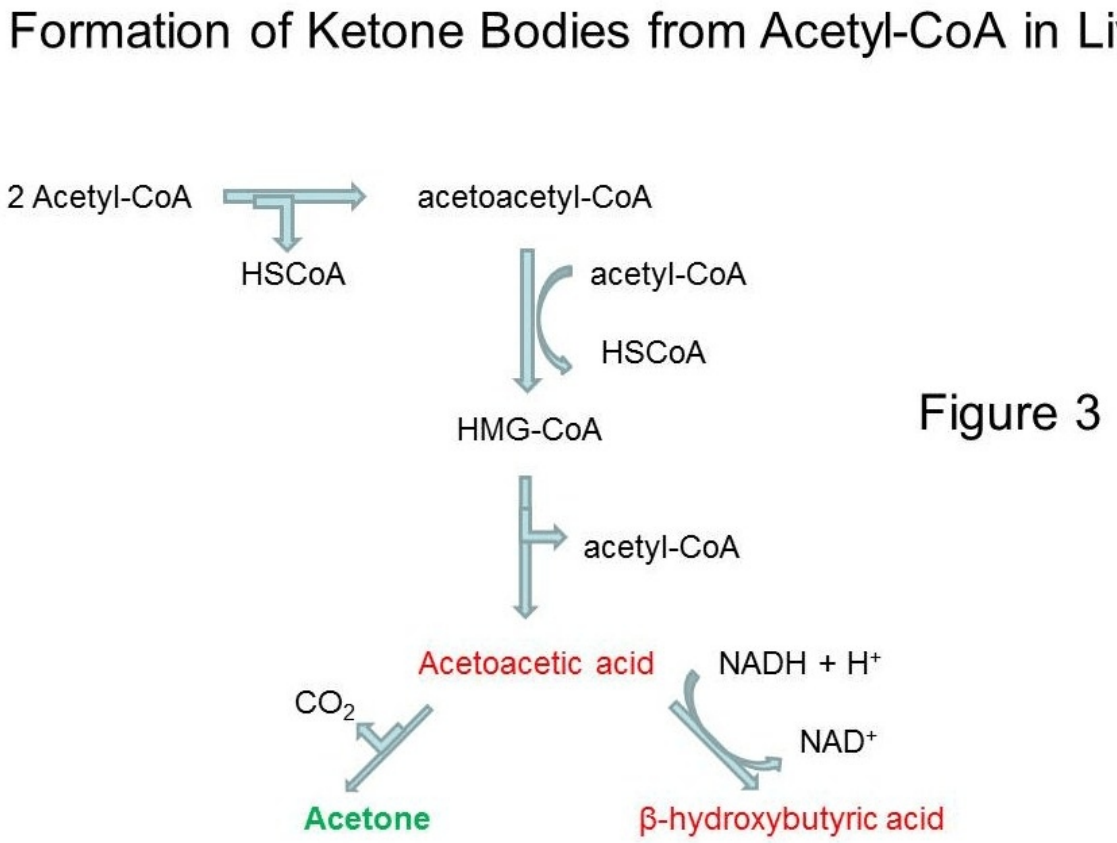


Figure 3: When *fatty acid* β-*oxidation* is optimally running, such as in much reduced carbohydrate intake dieting, starvation, or untreated diabetes, so much *acetyl-CoA* is produced that it all cannot be utilized. This is because much of the *oxaloacetic acid* (*TCA cycle*, Figure 2) is being drawn off to make *glucose* in liver cells. The excess *acetyl-CoA* is shunted to another process where it is converted to the *acidic* molecules called *ketone bodies* as shown in the figure. Two principal *ketone bodies* arise, *acetoacetic acid* and β-*hydroxybutyric acid*. These two *ketone bodies* are dumped into the blood stream by the liver so they may be transported throughout the body and absorbed by other organ and tissue cells to use in making *ATP* energy. An interesting note to this is that *acetoacetic acid* is *thermally unstable* and *spontaneously* breaks down in blood to produce some *acetone*, which is exhaled in the breath of an untreated Type I diabetic, and can be detected by smell. Finger nail polish remover has *acetone* as the solvent is gives the characteristic odor of the *acetone*.

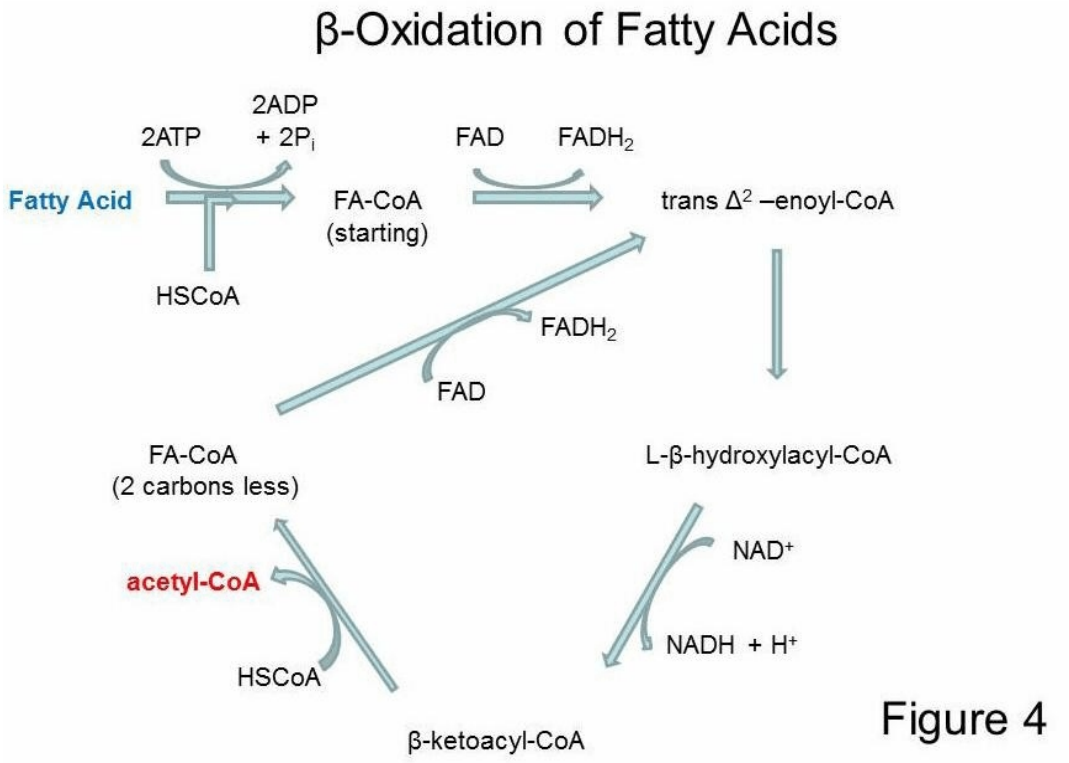


Figure 4

Figure 4: β-*Oxidation* is the means by which energy production occurs in absence of sufficient carbohydrate intake. As with *glycolysis* (Figure 1), where the *glucose* was *activated* by reaction with *ATP*, the *fatty acid molecule* is also *activated*. In this case, it is activated by becoming a *fatty acyl-CoA*, which requires *2 ATP* molecules to provide the energy to do so. The fatty acid molecule undergoes *oxidation* at what is the carbon number three of the chain (also known as the β *carbon*) hence the name of the process. It is a *spiraling process*, not a cycle as with *TCA*, since for each round, an *acetyl-CoA* (2 carbon fragment) is split off. Each round results in two carbons cut off the fatty acid chain length yielding an *acetyl-CoA*. Also *reducing power* arises in the form of *NADH* and $FADH_2$, which enter the *Electron Transport Chain* also. As β-*oxidation* is a *mitochondrial* process, collocated with the *TCA cycle*, the *acetyl-CoA* is in principal ready to enter the *TCA cycle* for further processing, ultimately to make copious quantities of *ATP*.

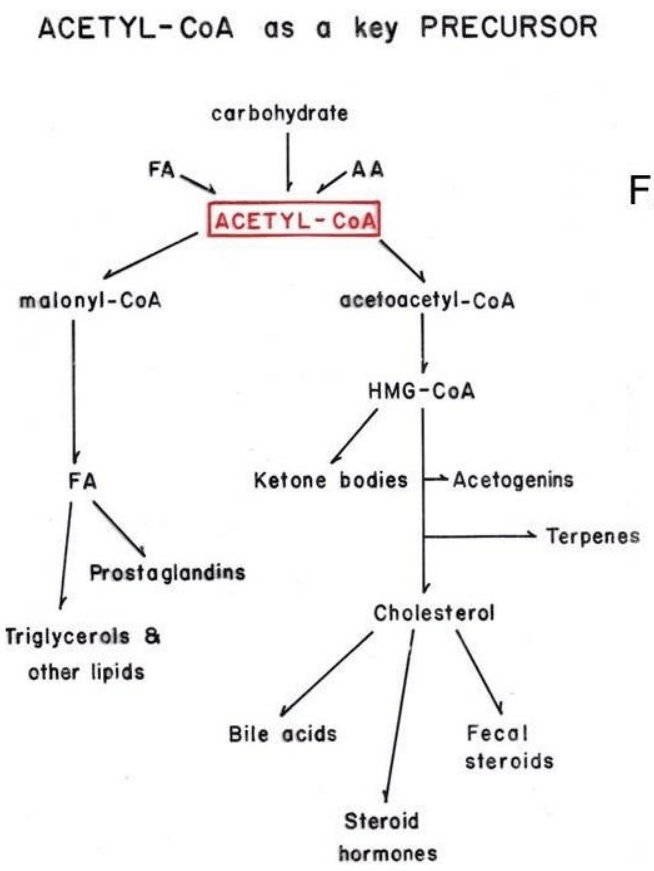


Figure 5

Figure 5: *Acetyl-CoA* is an important molecule in biological systems. It arises not only in several *catabolic* processes, it is a precursor for a number of *anabolic* processes. One can follow the "trail" of *carbohydrate* yielding *acetyl-CoA*, which in turn leads to *HMG-CoA*, and from that to either *ketone bodies* (if β-*oxidation* is operating), or *cholesterol* (if very high carbohydrate intake is in play).

Table 1: Number of Minutes Continuous Activity To Burn 300 Calories (300 kcal) for Given Body Weight*							
Weight (pounds)	120	140	160	180	200	220	240
Cycling: Stationary	66	57	50	44	40	36	33
Outdoor (Leisure)	83	71	62	55	50	45	41
Walking: 2.5 mph	110	94	83	73	66	60	55
3.0 mph	94	81	71	63	57	52	47
3.5 mph	83	71	62	55	50	45	41
Water Aerobics	83	71	62	55	50	45	41
Lap Swimming	41	35	31	28	25	23	21
Yoga	83	71	62	55	50	45	41
Resistence Exercise	55	47	41	37	33	30	28
Dancing: Aerobic	55	47	41	37	33	30	28
Low-Impact Aerobic	66	57	50	44	40	36	33
Ballroom-fast	60	52	45	40	36	33	30
Ballroom-slow	110	94	83	73	66	60	55
Golfing (Walking)	73	63	55	49	44	40	37
Raking Lawn	83	71	62	55	50	45	41
Lawn Mowing: Walking Power Mower	73	63	55	49	44	40	37
Riding Mower	132	113	99	88	79	72	66
Vacuuming/Sweeping	132	113	99	88	79	72	66

* John M. Jakicic, Kristine Clark, Ellen Coleman, Joseph E. Donnelly, John Foreyt, Edward Melanson, Jeff Volek, and Stella L. Volpe, "Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults", Medicine and Science in Sports and Exercise 33(12), p. 2152 (2001)

Table 2: Recommended Daily Allowances (mg) of Vitamins, Adults 19+ *				
Nutrient	Male		Female	
	19-50 yrs	> 50 yrs	19-50 yrs	> 50 yrs
A	0.9	0.9	0.7	0.7
B1 (Thiamin)	1.2	1.2	1.1	1.1
B2 (Riboflavin)	1.3	1.3	1.1	1.1
B3 (Niacin)	16	16	14	14
B5 (Pantothenic Acid)	5	5	5	5
B6 (Pyridoxine)	1.3	1.7	1.3	1.5
B12 (Cyanocobalamin)	0.0024	0.0024	0.0024	0.0024
Biotin	0.03	0.03	0.03	0.03
Choline	550	550	425	425
Folic Acid	0.4	0.4	0.4	0.4
C	90	90	75	75
D	0.005	0.01	0.005	0.01
E	15	15	15	15
K	0.12	0.12	0.09	0.09

* Health Supplements Nutritional Guide, www.healthsupplementsnutritionalguide.com/recommended-daily-allowances.html, accessed 17 May 2016

Table 3: Recommended Daily Allowances (mg) of Minerals, Adults 19+ *				
Nutrient	Male		Female	
	19-50 yrs	> 50 yrs	19-50 yrs	> 50 yrs
Calcium	1000	1200	1000	1200
Chloride	2300	2000	2300	2000
Chromium	0.035	0.03	0.025	0.02
Copper	0.9	0.9	0.9	0.9
Fluoride	4	4	3	3
Iodine	0.15	0.15	0.15	0.15
Iron	8	8	18	8
Magnesium	400-420	420	310-320	320
Manganese	2.3	2.3	1.8	1.8
Molybdenum	0.045	0.045	0.045	0.045
Phosphorus	700	700	700	700
Potassium	4700	4700	4700	4700
Sodium	1500	1300	1500	1300
Selenium	0.055	0.055	0.055	0.055
Zinc	11	11	8	8

* Health Supplements Nutritional Guide, www.healthsupplementsnutritionalguide.com/recommended-daily-allowances.html, accessed 17 May 2016

Table 4: Food Components-Recommended Daily Values (grams) for Adults*	
Food Component	Daily Value
Cholesterol	0.3
Dietary Fiber	25
Protein	50
Saturated Fat	20
Total Carbohydrate	300
* Guidance For Industry: A Food Labeling Guide (14. Appendix F. Calculate The Percent Daily Value For The Appropriate Nutrients), January 2013, www.fda.gov/Food/GuidanceRegulation, accessed 17 May 2016	

REFERENCES & SUPPLEMENTARY NOTES

1. ATP: Adenosine TriPhosphate, the most important biological energy packing molecule

2. Adult Obesity Facts, Centers for Disease Control and Prevention (CDC), www.cdc.gov/obesity/data/adult.html, accessed 3 June 2016

3. Stedman's Medical Dictionary, 25th Ed., Williams & Wilkins Publ., 1990, p. 952

4. Today's students learn about the conservation of matter and energy as a result of Einstein's world famous equation $E = mc^2$, which is a mathematical way of saying that matter and energy are interchangeable, or one can be converted to the other. A nuclear bomb or a nuclear reactor work as they do by converting matter to huge amounts of energy. In fact, matter can be viewed as "condensed" energy. It is important here to recognize that the processes of such "nuclear reactions" are not chemical reactions. Chemical reactions do not destroy matter (in any measurable way).

5. Mass and weight are two very different concepts. Mass is the quantity of matter present in a substance, while weight is the force the Earth exerts on it at sea level due to the Earth's gravitational field. As an example, a one kilogram mass has a weight on Earth of 2.2 lbs. On the Moon that same one kilogram mass would have a weight of 0.34 lbs. However, they tend to be used interchangeably.

6. For those curious how this calculation comes about, two points are in play. First we must raise the temperature of the quantity of water from 25°C up to 100°C, and then second we must impart

the necessary heat of vaporization to that quantity of water to make it vaporize at 100°C. The first part entails the equation q1 = msΔT, where q1 is the heat energy necessary to change the temperature of a quantity of water, m is the mass of water in question, s is the specific heat of water (here I use s = 1 cal/g °C), and ΔT is the change in temperature of the quantity of water, here 100°C - 25°C = 75°C, thus for the first part, q1 = 75m, where we have to determine what m the mass of water is. The second part we must determine the amount of heat energy imparted to that same quantity of water (m here) to cause it to boil at 100°C. That requires the use of the heat of vaporization, which for one gram of water is 539 cal/g. Thus the quantity of water m must also be multiplied by 539 and both expressions combined and set equal to the total heat imparted to the water. Our 200 lb male caloric ("heat") intake is 200 x 11 x 1000 (the 1000 converts dietetic Calories to thermodynamic calories) yielding 2,200,000 cal. Thus:

$$2{,}200{,}000 \text{ cal} = 75m \text{ cal} + 539m \text{ cal} = 614m \text{ cal}$$

$$m = 2{,}200{,}000/614 = 3583 \text{ g of water}$$

That is 0.95 or almost a full gallon of water (3780 g). That is a significant amount of heat energy.

7. A 5% reduction per day is not drastic. Even a 10% reduction may be workable. Clearly the greater the initial static weight, the greater the quantity of caloric reduction will be. For a male weighing 400 lbs, the 5% reduction is 200 Calories in round numbers. This is still a manageable number of fewer Calories. A 20% reduction for the 200 lb male is 440 Calories and for the 400 lb male, 880 Calories. This level of reduction will likely be noticed by the brain and resisted with "cravings".

8. John M. Jakicic, Kristine Clark, Ellen Coleman, Joseph E. Donnelly, John Foreyt, Edward Melanson, Jeff Volek, and Stella L. Volpe, "Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults", Medicine and Science in Sports and Exercise 33(12), p. 2152 (2001)

9. Lakatos Laszio and Janka Zoltan (2008), "Evolution of Human Brain and Intelligence", *Ideggyogyaszati szemle* **61(7-8)**, 220-229

10. As with many subjects raised or mentioned herein, one may consult any biochemistry text book and simply look up the term in the index, go to that (or those) page(s) and read more on that topic. It is well worth while to do so, if you are not put off by the confluence of the subjects of chemistry and biology.

11. Starches are plant polymers consisting of glucose molecules joined in what are termed by biochemists as α(1-4)-O-glycosidic linkages of the main chain, while there are branches arising at regular intervals with joints consisting of α(1-6)-O-glycosidic links. Cellulose is strictly a linear form of glucose molecules joined together in β(1-4)-O-glycosidic linkages. Humans cannot digest cellulose as we lack the necessary enzyme (a β-glucosidase) to do so. We can digest starches as we have the enzymes to do so. One is in saliva known as α-amylase, an α-glucosidase.

12. In ruminants such as cows, bacteria in their stomach (multi-chambered at that) actually break down the *cellulose* to glucose. The bacteria have an enzyme called a β-*glucosidase* that humans

do not.

13. In muscle cells, the hormone *epinephrine* (formerly called *adrenaline*) acts on muscle cells, spurring muscle cell *anaerobic glycolysis* necessary for muscular contractions, the so-called *fight or flight* response considered in biology classes. Muscles use their own separate store of *glycogen* to provide the glucose. Unlike liver, muscle glucose, once in the muscle cell, never gets out of the cell.

14. Proteolysis is generally the breakdown of body muscle (such as skeletal muscle like biceps, triceps, etc.). This is different from the breakdown of ingested protein which is a result of and characterized as *digestion* and takes place in the stomach and small intestines.)

15. The reader may notice that I do not speak in absolutes such as this is turn off while that is turn on. Biochemical processes do not operate as a light switch in which a light is either on or off. Rather they operate as though a dimmer switch is constantly changing its setting from all on to very nearly off, but always a residual effect when even disfavored.

16. The liver (*hepatic*) enzyme that does this is called *rhodanese*.

17. It should be noted that pyrolysis, the burning of organic material such as meats on the stove or outdoor grill can also produce these polyaromatic hydrocarbons.

18. Eric R. Taylor, Kenneth J. Miller and Anthony J. Bleyer (1983), "Interactions of Molecules with Nucleic Acids. X. Covalent Intercalative Binding of the Carcinogenic BPDE I(+) to Kinked DNA", *J. Biomolecular Structure and Dynamics* **1**, 883-904

and

Eric R. Taylor, Kenneth J. Miller and Josef Dommen (1985), "A Mechanism for the Stereoselectivity and Binding of Benzo[a]pyrene Diol Epoxides to DNA", in Polycyclic Hydrocarbons and Carcinogenesis, Ronald G. Harvey (Ed.), ACS Symposium Series 283, 239-288

and

Kenneth J. Miller, Eric R. Taylor, Josef Dommen, and Jonathan J. Burbaum (1985), "Stereoselectivity of Benzo[a] Pyrene Diol Epoxides by DNA For Adduct Formation with N2 of Guanine", in *Molecular Basis of Cancer, Part A: Macromolecular Structure, Carcinogens, and Oncogenes*, Alan R. Liss, Inc., pp. 187-197

19. Michelle Bonnett and Eric R. Taylor (1989), "The Structure of the Aflatoxin B_1-DNA Adduct at N7 of Guanine. Theoretical Intercalative and Covalent Adduct Models", *J. Biomolec. Struct. & Dynam.* **7**, 127-149

and

Eric R. Taylor (1992) "Aflatoxin B_1 and DNA Adducts. Proposed Model for Surface Noncovalent and Covalent Complexes with N7 of Guanine. II.", *J. Biomolec. Struct. & Dynam.* **10(3)**, 533-550

20. Lactic acid is the end product of anaerobic glycolysis. When muscles are actively contracting, oxygen levels in blood are low, so glycolysis does not end at the normal aerobic end product pyruvate. But lactic acid can be converted back to glucose. The lactic acid is transferred across the muscle cell membrane into blood, which in its circulation throughout the cardiovascular system, also passes by the liver, which absorbs it into liver cells, which convert it back to glucose. The formed glucose can either be dumped back into the blood stream to continue supplying glucose to brain and muscle, whose own glucose supply (muscle glycogen) needs replenishment, or the formed glucose can be stored in the liver cell's own glycogen store.

21. In a Type I diabetic, the issue is a lack of insulin secretion of the pancreas even though blood glucose levels may actually be very high. The glucose levels can be so high, that some glucose is passed in the urine, and historically the presence of glucose in urine was determined by the use of a analytic test called the *Benedict's Test*. This test added several drops of a solution called *Benedict's Solution* which contained copper ion (a blue solution because of the double positive charge on the copper ion). The solution would react with the glucose, producing a red precipitate which was a single positive charge copper ion and a positive test for glucose in urine and a virtual certain confirmation of diabetes.

22. Technically, while you sleep overnight, you are fasting. Your brain's need for glucose is provided by the release of glucose from the liver's *glycogen* store. As for muscle and heart, they operate on fatty acids as the energy source overnight. Though glucose is soluble in blood, fatty acids a re not, and they are carried in blood bound to blood *serum albumin*, a globular protein that makes up roughly about 50% of blood's dry mass.

23. The fatty acids used by resting muscles is transported to the muscle cells in blood bound to a protein in the blood, serum albumin, since fatty acids are not water or blood soluble themselves.

24. When I say make an ATP from the energy within say glucose, biochemically this means take another precursor molecule of ATP, an ADP, and add a phosphate moiety to it. However, ATP molecules, as is the case with other *mononucleotides* as they are called, can be made in the body cells, one atom at a time. See a biochemistry textbook for this process.

25. Type II diabetes, or adult onset diabetes, occurs much later in life among elderly. Unlike Type I which is juvenile onset and a result of insufficient or a complete lack of pancreatic production of insulin due to some pathologic cause, Type II arise as the adults cells become less responsive to binding of insulin to susceptible cell receptors. Though insulin treatments can be employed in countering this type of diabetes, diet control of carbohydrate and sugar intake also is a means of lessening the effects.

26. Cholesterol synthesis is one of the very high energy demanding processes. There are about 30 carbon atoms in a molecule of cholesterol and it requires at least 30 ATP molecules to build a cholesterol molecule. High carbohydrate intake can provide the energy for this, but if β-*oxidation* is providing the energy, under the control of *glucagon*, the body has mechanisms in place to suppress anabolic processes for which energy availability is lacking.

27. Bacteria are *prokaryotic* cells, meaning they have no *nucleus* that houses their genetic material, the *DNA*. *Eukaryotic* cells do have a *nucleus*, another *organelle*, in which is housed the genetic material, the *DNA*, that determines if the cell is animal or plant, mouse or man.

28. an NADH and an $FADH_2$

29. Postprandial (Stage 1); Post absorptive (Stage 2); Starvation (Stage 3); Prolonged Starvation (Stage 4); Terminal (Stage 5)