CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 6:

- **Metabolism, Feasting, Fasting, and Energy Balance**

When you eat too much you get fat; when you eat too little you get thin. Everybody knows these simple facts, but nobody knows exactly how to account for them. The mission of this session is to shed some light on what we do know and to provide answers to some of the questions people often ask about diets.

- What makes a person gain weight?
- Are carbohydrate-rich foods more fattening than other foods?
- What's the best fuel for an athlete?
- What's the best way to lose weight?
- Is fasting dangerous?
- Are low-carbohydrate diets dangerous?

The answers to these and many other questions lie in an understanding of metabolism. Metabolism could be defined as the way the body handles the energy nutrients.

Metabolism

Metabolism is the sum total of all the chemical reactions that go on in living cells.
Meta = among
Bole = change

Starting Points

The first four sessions introduced the energy nutrients – carbohydrate, fat, and protein – as they are found in foods and in the human body. Session 5 followed the nutrients through digestion to the simpler units they are composed of and showed these units disappearing into the blood. Four of these units will be followed here:

1. **Carbohydrate** – During digestion, all available carbohydrates are broken down to monosaccharides and absorbed into the blood. Fructose and galactose are then mostly taken into liver cells and converted to glucose or to very similar compounds. To follow carbohydrate through metabolism we will simply follow glucose.
2. **Lipids** – Most of the dietary lipids are triglycerides. The basic units these are composed of are glycerol and fatty acids. To follow lipids through metabolism we will follow glycerol and fatty acids.
3. **Protein** – Protein is ultimately digested to amino acids; these are the units we will follow through metabolism.

Building Body Compounds

You already know what may happen to some of these basic units when their energy is not needed by the cells. They may be stored "as is," and then used to build body compounds. Glucose units may be strung together to make glycogen chains. Glycerol and fatty acids may be assembled into triglycerides. Amino acids may be used to make proteins. These building reactions, in which simple compounds are put together to form larger, more complex structures, involve doing work and so require energy. They are called anabolic reactions, and are always represented by "up" arrows in diagrams such as those in this session.

Anabolism (an-ABB-o-lism)

Anabolisms are reactions in which small molecules are put together to build larger ones. Anabolic reactions consume energy and often involve reduction.
Ana = up

Catabolism (cuh-TAB-o-lism)

Catabolisms are reactions in which large molecules are broken down to smaller ones. Catabolic reactions release energy and often involve oxidation.

Pyruvate (PIE-roo-vate)

Pyruvate is pyruvic acid; a 3-carbon compound derived from glucose and certain amino acids in metabolism. The term pyruvate means a salt of pyruvic acid. (Throughout this course the ending ate is used interchangeably with ic acid; for our purposes they mean the same thing.)

Glycolysis (gligh-COLL-uh-sis)

Glycolysis is the metabolic breakdown of glucose to pyruvate.
Glyco = glucose
Lysis = breakdown

Breaking Down Nutrients for Energy

If the body needs energy, it may break apart any or all of these four units into smaller fragments. The breakdown reactions are called catabolic reactions. They release energy. Much of the body's catabolic work is done by enzymes in the liver cells, and all the reactions described in this session can take place there.

At this point, it must be recalled that although glucose, glycerol, fatty acids, and amino acids are the basic units we get from food, they are composed of still smaller units, the atoms. During metabolism, the body actually separates these atoms from one another.

The main point to notice in the follow discussion is that compounds that have a 3-carbon skeleton can be used to make the vital nutrient glucose. Those that have 2-carbon skeletons cannot.

What happens to these compounds inside of cells can be best understood by starting with glucose. Two new names appear – pyruvate (3 Cs) and Acetyl-CoA (2 Cs) – and the rest of the story falls into place around them.

Glucose

In breaking down, glucose first splits in half, releasing energy. One product is the 3-carbon compound pyruvate, and the other is a 3-carbon compound that is converted to pyruvate, so that two identical halves result from this step.

Should a cell "change its mind" after splitting glucose to pyruvate, it could reverse this step. It could put the two halves back together to make glucose again.

If the cell still needs energy, however, it breaks the pyruvate molecules apart further, cleaving a carbon from each. The lone carbon is combined with oxygen to make carbon dioxide, which is released into the blood, circulated to the lungs, and breathed out. The 2-carbon compound that remains is acetate (Acetyl-CoA).

Should the cell change its mind at this point and want to retrieve the shed carbons and remake glucose, it could not do so. The step from pyruvate to Acetyl-CoA is metabolically irreversible. It is a one-way step.

The carbon removed from the pyruvate ends up being combined with oxygen to make carbon dioxide. The person had to breathe oxygen into the lungs, had to attach it to a carrier (hemoglobin) in the red blood cells, and had to bring it to the metabolizing cells to make it available for this purpose. Everyone knows you need to breathe harder when you are using energy faster (exercising), but not everyone "sees" what's happening. Energy nutrients are being broken down to provide that energy, and oxygen is always ultimately involved in the oxidation process.

Finally, Acetyl-CoA may be split, yielding two more carbon dioxide molecules. The energy released in this step powers most of the cell's activities. In short, the main steps in the metabolism of glucose are glucose to pyruvate to Acetyl-CoA to carbon dioxide. Notice (again) that only the first step is reversible. The process by which Acetyl-CoA splits and releases its energy is known as the TCA cycle.

CoA (coh-AY)

As pyruvate loses a carbon and becomes a 2-carbon compound (acetate, or acetic acid), a molecule of CoA is attached to it, making Acetyl-CoA (ASS-uh-teel, or uh-SEET-ul, co-AY).

TCA (tricarboxylic acid) or Krebs Cycle

The reactions by which the complete oxidation of Acetyl-CoA is accomplished are those of the TCA (tricarboxylic acid) or Krebs cycle (named for the biochemist who elucidated them) and oxidative phosphorylation. The net result is that Acetyl-CoA splits, the carbons combine with oxygen, and the energy originally in the Acetyl-CoA becomes available for the body's use.

Glucose Breakdown

These are the processes by which energy from glucose is made available to do the cells' work. Many chemical reactions are involved. Ultimately, glucose is completely disassembled to single-carbon fragments, the fragments are combined with oxygen to form carbon dioxide, and most of the freed energy is used to make other compounds such as ATP, glycogen, and fat. ATP is a short-term energy-carrying compound. Glycogen and fat are longer-term energy-storage deposits.

Caution:

Most people spend their entire lives without ever making the acquaintance of pyruvate and acetyl CoA, yet chemists and nutritionists can become quite excited talking about them. The behavior of these two compounds explains the most interesting and important aspects of nutrition and makes it possible to answer questions like those asked at the outset. Are carbohydrate-rich foods more fattening than other foods? What's the best energy fuel for an athlete? What's the best way to lose weight? Is fasting dangerous? Are low-carbohydrate diets dangerous?

A person who understands the basics of metabolism can choose what fuel to burn for various purposes. The enlightened athlete knows, for example, that in some athletic events the muscles use fat and glucose, while in others, they require glucose only. The enlightened dieter knows how to encourage the use of fat rather than muscle-protein kcalories during a weight-loss program. It all hinges on which fuels can be converted to glucose and which cannot. The parts of protein and fat that can be converted to pyruvate (3 Cs) can provide glucose for the body; those that are converted to Acetyl-CoA cannot provide glucose. And glucose is all-important.

Glycerol and Fatty Acids

The glycerol (3 Cs) is easily converted to pyruvate (also 3 Cs, but with a different arrangement of Hs and OHs on the Cs), and then may go either "up" to form glucose or "down" to form acetyl CoA and finally carbon dioxide. The three fatty acids are taken apart two carbons at a time to make Acetyl-CoA. Because the arrow from pyruvate to Acetyl-CoA goes one way (down) only, the fatty acids cannot be used to make glucose.

The significance of this is that fat, for the most part, cannot normally provide energy for the organs (brain, nervous system) that require glucose as fuel. Remember that almost all dietary lipid is triglyceride, and that the typical triglyceride consists of a molecule of glycerol (3 Cs) and three fatty acids (each about 18 Cs on the average, or about 54 Cs in all). True, the glycerol can yield glucose, but that represents only 3 out of 57 parts of the fat molecule – about 5 percent of its weight. Thus, fat is a very poor, inefficient source of glucose by itself. About 95 percent of it cannot be converted to glucose at all.

ATP (adenosine triphosphate)

The body as a whole stores its excess energy in special storage organs; the liver and muscle (as glycogen) and the fat cells (as fat). However, each cell also has to have a ready supply of "instant energy." This is like storing money in the bank but also keeping pocket money in cash. The cells' cash is adenosine triphosphate (ATP).

When the cell needs energy, each ATP molecule releases one phosphate group. The packet of energy in the broken bond is used, and the phosphate stays in the fluid of the cell along with the adenosine diphosphate (ADP) that is left. Whenever ATP is broken apart like this, its energy is used to do some work for the cell.

As the cell gradually uses up its energy, the amount of ATP falls, and that of ADP rises. The increased amount of ADP generates a signal that the cell needs energy; so units such as glucose, available in the blood from food, are taken into the cell and broken down to carbon dioxide, water, and energy. The cell deposits the released energy in another high-energy bond, hooking phosphate back onto ADP, reforming ATP. Thus balance is restored.

If no energy units from food are available, glucose and fat drawn from body stores supply the energy to rebuild ATP. In the extreme case of starvation, even body proteins are dismantled in response to the low ATP levels of the cells. Thus "bank" energy is converted to "cash" energy.

An abundance of ATP in the cells also serves as a signal. It tells the liver to route any remaining energy units to storage. Thus "cash" energy can be put back in the "bank."

Amino Acids

Ideally, amino acids will be used to replace needed body proteins, and will not be catabolized at all. But if they are needed for energy, they enter the metabolic pathway. They are stripped of their nitrogen and then catabolized in a variety of ways. The end result is that about half of the amino acids can be converted to pyruvate; the other half go either to Acetyl-CoA or directly into the TCA cycle. Those that can be used to make pyruvate can provide glucose for the body. Thus protein, unlike fat, is a fairly good source of glucose when carbohydrate is not available; about 50 percent of it can be used this way.

Amino acids break down when energy needs are not met by carbohydrate and fat, as just described, but they also break down in the same way under another set of conditions: when surplus kcalories and protein are consumed. Surplus protein cannot he stored in the body as such; it has to be converted to other compounds. If you eat more protein than you can use at a given time, the excess amino acids soon lose their nitrogens, and most are converted to acetyl CoA (either directly or indirectly, through pyruvate). This Acetyl-CoA is not broken down further, because energy is not needed. Instead, it is strung together into chains – fatty acids – and stored in body fat. Thus even the so-called "lean" nutrient, protein, can make you fat if you eat too much of it.

Caution:

The high-protein dieter objects to the statement above, saying, "Protein makes you thin!" In fact, many weight-loss diets are based on high protein intakes, making the claim that "Protein will give you energy but will not make you fat." Eat all you want – just stay away from fattening carbohydrates."

The secret of these diets, when they do seem to promote weight loss is that meals without carbohydrate are in truth so unappetizing that people who ingest them eat much less total food than they normally do. Try eating your breakfast of bacon, eggs, toast, and juice without the toast and juice. Have a ham and cheese sandwich without the bread, and a steak, potatoes, and pea dinner without the potatoes and peas. You'll be surprised how quickly you lose your enthusiasm for the permitted foods. (Some people report, after eating nothing but bacon, eggs, ham, cheese, and steak for a few days, that they start dreaming of toast and juice!)

This method of weight loss may sound fine to the person who wants to lose pounds fast, but the next few sections of this course should convince any sane dieter otherwise. Meanwhile, it should now be clear that protein, in and of itself, is not nonfattening. People who eat huge portions of meat, even lean meat, and other protein-rich foods may wonder why they have a weight problem. It may be those very foods that are causing the trouble.

There is a message for the athlete in these metabolic facts about protein, too. Excess protein is not a muscle-building food; it's a fat-building food. To the extent that protein is used for energy, carbohydrate would do the job just as well. In other words, there is no point to loading up on protein for any reason.

How Amino Acids Enter the Metabolic Path

About half of the amino acids can convert to pyruvate (and therefore glucose); about half convert to acetyl CoA or go directly into the TCA cycle (and therefore cannot yield glucose).

Gluconeogenisis (gloo-co-nee-o-GEN-uh-sis)

The making of glucose from protein or fat is gluconeogenisis. About 5 percent of fat (the glycerol portion of triglycerides) and about 50 percent of protein (the glucogenic amino acids) can be converted to glucose.)
Gluco = glucose
Neo = new
Genesis = making

Deamination

Deamination is the removal of the amino (NH_2) group from a compound such as an amino acid.

Urea (you-REE-uh)

Urea is the principal nitrogen-excretion product of metabolism. Two ammonia fragments are combined with a carbon-oxygen group to form urea.

What happens to the Nitrogen?

When amino acids are degraded for energy or to make fat, the first step is removal of their nitrogen-containing amino groups, a reaction called deamination. The product is ammonia; chemically identical to the ammonia in the bottled cleaning solutions used in hospitals and in industry. It is a strong-smelling and extremely potent poison.

A small amount of ammonia is always being produced by liver deamination reactions. Some of this ammonia is captures by liver enzymes and used to synthesize other amino acids, but what cannot be used is quickly combined with a carbon-oxygen fragment to make urea, an inert and less toxic compound.

Urea is released from the liver cells into the blood, where it circulates until it passes through the kidneys. One of the functions of the kidneys is to remove urea from the blood for excretion in the urine. Urea is the body's principal vehicle for excreting unused nitrogen; water is required to keep it in solution and excrete it. This explains why people who consume a high-protein diet must drink more water than usual.

Putting It All Together

After a normal meal, if you do not overeat, the body handles the nutrients in the following fashion.

- The carbohydrate yields glucose; some is stored as glycogen, and some is taken into brain and other cells and broken down through pyruvate and acetyl CoA to provide energy.
- The protein yields amino acids, and some are used to build body protein. However, if there is a surplus or if not enough carbohydrate and fat are present to meet energy needs, some amino acids are broken down through the same pathways as glucose to provide energy.
- The fat yields glycerol and fatty acids; some are put together and stored as fat, and others are broken down to acetyl CoA and provide energy.
- A few hours after the meal, the stored glycogen and fat begin to be released from storage to provide more glucose, glycerol, and fatty acids to keep the energy flow going.
- When all the energy supplied from the last meal has been used up and reserves of these compounds are running low, it is time to eat again.

The average person consumes more than a million kcalories a year and expends more than 99 percent of them, maintaining a stable weight for years on end. This remarkable achievement, which many people manage without even thinking about it, could be called the economy of maintenance. The body's energy budget is balanced. Some people, however, eat too little and get thin; others eat too much and get fat. The possible reasons why they do are explored in Session 7; the metabolic consequences are discussed here.

The Economy of Feasting

The following will show how metabolism favors fat formation when you eat too much of any energy nutrient.

- Surplus carbohydrate (glucose) is first stored as glycogen, but there is a limit to the capacity of the glycogen-storing cells. Once glycogen stores are filled, the overflow is routed to fat. Fat cells enlarge as they fill with fat, and the body's fat-storing capacity seems to be able to expand indefinitely. Thus excess carbohydrate can contribute to obesity.
- In the same way, surplus dietary fat can contribute to the fat stores in the body. It may break down to fragments such as acetyl CoA, but if energy flow is already rapid enough to meet the demand, these fragments will not be broken down further. Instead, they will be routed to the assembly of triglycerides and stored in the fat cells.
- Finally, surplus protein may encounter the same fat. If not needed to build body protein or to meet present energy needs, amino acids will lose their nitrogens and be converted through the intermediates, pyruvate and acetyl CoA, to triglycerides. These, too, swell the fat cells and increase body weight.

The Economy of Fasting

Even when you are asleep and totally relaxed, the cells of many organs are hard at work spending energy. In fact, the work that you are aware of, that you do with your muscles during waking hours represents only about a third of the total energy you spend in a day. The rest is the metabolic work of the cells, for which they constantly require fuel.

The body's top priority is to meet these energy needs, and its normal way of doing so is by periodic refueling – that is, by eating. When food is withdrawn, the body must find other fuel sources in its own tissues. If people choose not to eat, we say they are fasting; if they have no choice (as in a famine), we say they are starving; but there is no metabolic difference between the two. In either case the body is forced to switch to a wasting metabolism, drawing on its reserves of carbohydrate and fat and, within a day or so, on its vital protein tissues as well.

Fuel must be delivered to every cell. As the fast begins, glucose from the liver's stored glycogen and fatty acids from the body's stored fat are both flowing into cells, breaking down to yield acetyl CoA, and delivering energy to power the cells' work. Several hours later, however, most of the glucose is used up, and the liver glycogen is being exhausted.

At this point, most of the cells are depending on fatty acids to continue providing their fuel. But the brain cells cannot; they still need glucose. (It is their major energy fuel, and even if other energy fuel is available, glucose has to be present to permit their energy-metabolizing machinery to work.) Normally the nervous system (brain and nerves) consumes about two-thirds of the total glucose used each day – about 400 to 600 kcalories' worth.

The brain's special requirement for glucose poses a problem for the fasting body. The body can use its stores of fat, which may be quite generous, to furnish most of its cells with energy, but for the brain and nerves it must supply energy in the form of glucose. This is why body protein tissues, such as muscle, always break down to some extent during fasting. Only those amino acids that yield 3-carbon pyruvate can be used to make glucose; and to obtain them, whole proteins must be broken down. The other amino acids, that cannot be used to make glucose, then have to be disposed of. This is an expensive way to gain glucose, but to extract a molecule of glycerol from a triglyceride obligates the body to dispose of some 50 or 60 carbons' worth of fatty acids, which is even more expensive. In the first few days of a fast, body protein provides about 90 percent of the needed glucose, and glycerol about 10 percent. If body protein loss were to continue at this rate, death would ensue within three weeks.

As the fast continues, the body adapts by producing an alternate energy source, ketones, by condensing together Acetyl-CoA fragments derived from fatty acids. Normally produced and used in only small quantities, ketones can serve as fuel for some brain cells. Ketone production rises until, at the end of several weeks, it is meeting about half or more of the nervous system's energy needs. Still, many areas of the brain rely exclusively on glucose, and body protein continues to be sacrificed to produce it.

Ketone (KEE-tone)

A ketone is a compound formed during the incomplete oxidation of fatty acids. Ketones contain a C=O group between other carbons; when they also contain a COOH (acid) group, they are called keto-acids. Small amounts of ketones are a normal part of the blood chemistry, but when their concentration rises, they spill into the urine. The combination of high blood ketones (ketonemia) and ketones in the urine (ketonuria) is termed ketosis.

Fasting

Living on (body) fat and (body) protein.

Fasting (early)

Protein is supplying glucose. Amino acids that can't generate glucose are degraded for energy.

Fasting (late)

Protein breakdown supplies some glucose for the brain. Ketone production helps to support brain function.

Low-Carbohydrate Diet

Living on (dietary and body) fat and protein almost exclusively.

Juice Fasting

Living on (dietary) carbohydrate and (body) fat.

Protein-Sparing Fast

Living on (dietary) protein, (body) fat, and (body) protein.

Caution:
During fasting, appetite is suppressed. It has been though that ketosis caused loss of appetite. The theory was that it would be an advantage to a person in a famine to have no appetite, because the search for food would be a waste of energy. When the person finds food and eats carbohydrate again, the body shifts out of ketosis, the hunger center gets the message that food is again available, and appetite returns. This hypothetical chain of events has served as justification for weight-loss routines, such as fasting and fad diets, that cause ketosis. However, it may be that any kind of food restriction, with or without ketosis, leads a person to adapt by losing appetite. An ordinal low-kcalorie diet can induce the same effect.

While the body is shifting to the use of ketones, it simultaneously reduces its energy output and conserves both its fat and lean tissue. As the lean (protein-containing) organ tissue shrinks in mass, it performs less metabolic work, reducing energy needs. As the muscles waste, they do less work, enhancing this effect. Because of the slowed metabolism, the loss of fat falls to a bare minimum – less, in fact, that the fat that would be lost on the low-kcalorie diet. Thus, although weight loss during fasting may be quite dramatic, fat loss may be less than when at least some food is supplied.

The adaptations just described – slowing of energy output and reduction in fat loss – occur in the starving child, the fasting religious person, and the malnourished hospital patient, and help to prolong their lives. The physical symptoms of marasmus include:

- Wasting
- Slowed metabolism
- Lowered body temperature
- Reduced resistance to disease

The body's adaptations to fasting are sufficient to maintain life for a long period. Mental alertness need not be diminished, and even physical energy may remain unimpaired for a surprisingly long time. Still, fasting is not without its hazards, as physician-supervised fasting has revealed. Among the multitude of changes that take place in the body are:

- Sodium and potassium depletion
- An increase in body uric acid
- A rise in blood cholesterol
- A decrease in thyroid hormone

The same alternations are seen in low-carbohydrate dieting. Renewed food intake, especially of carbohydrate, results in dramatic changes in the body's salt and water balance, accounting for most of the wide swings in body weight seen in people on fasts or low-carbohydrate diets.

The Low-Carbohydrate Diet

An economy similar to that of fasting prevails if a low-carbohydrate diet is consumed. Advocates of the low-carbohydrate diet would have you believe there is something magical about ketosis, something that promotes faster weight loss than a regular low-kcalorie diet. In fact, the low-carbohydrate diet presents the same problem as a fast. Once the body's available glycogen reserves are spent; the only significant remaining source of energy in the form of glucose is protein. The low-carbohydrate diet provides a little protein from food, but some must still be taken from body tissue. The onset of ketosis is the signal that this wasting process has begun.

In a diet that provides fewer than about 900 kcalories (for the average-sized adult), it is pointless to supply any protein at all, because the protein will only be used to provide energy, as carbohydrate would be used. Body protein is lost at the same rate in adults on such a diet whether or not they are given any food protein.

Caution:

One conclusion to draw from this is that a person who diets at the level of 900 kcalories a day might as well eat carbohydrate without protein, to spare body protein and allow efficient use of body fat. Carbohydrate-containing foods are less expensive than protein-rich foods, and both will serve the same purpose – supplying glucose. This is the choice made by the person on a juice fast, for the only energy nutrient juices contain is carbohydrate. But a wise conclusion is that such a diet is unnecessarily low in kcalories, even dangerously so. The person who wishes to lose body fat will select a balanced diet of 1,200 or more kcalories, one containing carbohydrate, fat, and protein. At this level, body protein will be spared, ketosis need not occur, vital lean tissues (including both muscle and brain) will not starve, and only the unwanted fat will be lost.

People are attracted to the low-carbohydrate diet because of the dramatic weight loss it brings about within the first few days. They would be disillusioned if they realized that much of this weight loss is a loss of glycogen and protein, and with them, quantities of water and important minerals. A dieter who boasts of losing seven pounds in two days on a low-carbohydrate diet must be unaware that at best, a pound or two is fat and five or six pounds are lean tissue, water, and minerals. Once "off" the diet, the dieter's body will avidly devour and retain these needed materials, and the weight will zoom back to within a few pounds of the starting point.

A warning is suggested by these facts. Beware of those who promote quick-weight-loss schemes. Learn to distinguish between loss of fat and loss of weight.

The Protein-Sparing Fast

A variant on fasting is the technique of ingesting only protein. The hope is that the protein will spare lean tissue and that the person will break down his own body fat at a maximal rate to meet his other energy needs. The protein, together with the body's lean tissues, are used to provide glucose. The idea sounded good when it was first suggested for use with very obese people, but it has met with mixed results. It seems effective only after considerable lean tissue has already been lost, at which time the body may be conserving itself quite efficiently anyway, and the fast has not been shown more effective than a mixture of protein and carbohydrate. Furthermore, it doesn't seem to "stick" very well; most people regain the lost weight.

Thus the protein sparing fast has to be judged at best a very moderate success and at worst a failure, for the ultimate criterion of success in any weight-loss program is maintenance of the new low weight.

The idea of a protein sparing fast originated with some responsible physicians who experimented carefully with it, using whole foods naturally rich in protein, such as fish and lean beef. Unfortunately, the idea was then seized upon and misused with the publication of a popular book, The Last Chance Diet, in 1977. Fad dieters, usually without any medical supervision, drank liquid protein potions prepared from low-quality sources, and lost dramatic amounts of weight – including, of course, lean tissue, water, and vital minerals. These “predigested” liquid proteins are of “notably lower quality” than food proteins, and cause dangerous alterations in heart rhythm. Within the year, 11 deaths had been ascribed to the fat, and the FDA had issued a stringent warning about liquid protein preparations. Since then, many more have died on the fast, due to sudden stopping of the heart caused probably by mineral losses.

The term protein sparing has also been used in another connection. Malnourished hospital patients also lose body protein, and this is especially likely, and especially dangerous, if they are simultaneously fighting infection. Physicians make every effort to prevent the loss of vital lean tissue by supplying amino acids as well as glucose in some form – through a vein if the patient can’t eat. The effort to provide protein-sparing therapy in these circumstances should not be confused with the profiteering of faddists who promote the protein sparing fast.

Moderate Weight Loss

The body’s cells and the enzymes within them make it their task to convert the energy nutrients you eat into those you need. They are extraordinarily versatile. They relieve you of having to compute exactly how much carbohydrate, fat, and protein to eat at each meal. As you have seen, they can convert either carbohydrate (glucose) or protein to fat. To some extent, they can convert protein to glucose. To a very limited extent, they can even convert fat (the glycerol portion) to glucose. But a grossly unbalanced diet or one that is severely limited in kcalories imposes hardships on the body. If kcalorie intake is too low or if carbohydrate and protein kcalories are undersupplied, the body is forced to degrade its own lean tissue to meet its glucose need.

Someone who wants to lose body fat must reconcile himself to the hard fact that there is a limit to the rate at which this tissue will break down. The maximum rate, except for a very large, very active person, is one to two pounds a week. To achieve weight loss that actually reflects body-fat loss, the most effective means is to adopt a balanced, low-kcalorie diet supplying all three energy nutrients in reasonable amounts while increasing energy expenditure by getting more exercise. In effect, this means adjusting the energy budget so that intake is 500 to 1,000 kcalories per day less than output. A person who wants to gain weight needs to make the opposite adjustment.

It might seem that the effort to lose or gain weight would involve tedious counting of kcalories, but this is not the case. The next two sections show how kcalorie input and kcalorie output can be estimated and balanced to achieve weight loss, gain, or maintenance.

Low-Kcalorie Diet

Living on food and body fat

1 Pound = 3,500 kcalories

A pound of body fat (adipose tissue) is actually composed of a mixture of fat, protein, and water and yields 3,500 kcalories on oxidation. A pound of pure fat (454 grams) would yield 4,086 kcalories at 9 kcalories per gram.

Calorimetry (cal-o-RIM-uh-tree)

A calorimetry is the measurement of energy as heat.
Calor = heat
Metron = measure

- 1 gram carbohydrate = 4 kcalories
- 1 gram fat = 9 kcalories
- 1 gram protein = 4 kcalories
- 1 gram alcohol = 7 kcalories

Direct Calorimetry

When an organic substance such as food is burned, the energy in the chemical bonds that held its carbons and hydrogens together is released in the form of heat. The amount of heat released can be measured; this direct measure of the amount of energy that was stored in the food’s chemical bonds is termed direct calorimetry.

Indirect Calorimetry

As the chemical bonds in food are broken the carbons © and hydrogens (H) combine with oxygen (O) to form carbon dioxide (CO2) and water (H_2O). Measuring the amount of oxygen consumed in the process gives an indirect measure of the amount of energy released termed indirect calorimetry.

Estimating kCalorie Intake from Food

To find out how many kcalories are in food, a laboratory scientist can burn the food in a bomb calorimeter. This device can reveal kcalorie values in two ways. Either it directly measures the heat given off (and kcalories are units of energy defined in terms of heat) or it measures the amount of oxygen consumed in the burning, an indirect measure of the kcalories produced.

The number of kcalories in a food as determined by direct calorimetry, however, is higher than the number of kcalories that same food would give to the human body. This apparent discrepancy is explained by the fact that the body does not metabolize all the food all the way to carbon dioxide and water as the calorimeter does. When the calorimeter-derived values are corrected for this discrepancy, they state accurately the number of kcalories a food provides to the body, thus permitting researchers to make useful tables presenting the energy values of foods.

Another way to arrive at food energy values is to compute them from the amounts of protein, fat, and carbohydrate (and alcohol, if present) found in them.

But looking up every food in kcalorie charts is boring and inconvenient, and only the most motivated will persist at it for long. For the rest of us who may want to keep track of kcalories, some acquaintance with and exchange system, provides a simpler method. With some practice, you can look at any plate of food and "see" the number of kcalories on it. Only seven values need to be learned as a start towards gaining this new skill.

Food kCalorie Values

1 c skim milk (for whole milk, add 2 fat)	80 kcal
½ c vegetable	25 kcal
1 portion fruit	40 kcal
1 portion bread or starchy vegetable	70 kcal
1 oz lean meat (for medium-fat meat add ½ fat) (for high-fat meat add 1 fat)	55 kcal
1 fat (1 tsp. fat or oil)	45 kcal
1 tsp. sugar	20 kcal

Caution:

Before leaving the subject of the energy in food it is only fair to mention another way of thinking about energy in relation to food. We normally ask, "How many kcalories are in that food?" Dr. Jean Mayer, formerly professor of nutrition at Harvard School of Public Health, has pointed out that the average consumer in the United States uses three times as much energy to bring food to the table as the average citizen of developing countries uses for all purposes. It's a complicated thought, because more than just electric or gas heat in your kitchen goes into the production of a food. Foods that cost little energy in your kitchen may cost incredible amounts of energy in the field or in processing.

Along the same lines, the nutrition educator Dr. Isobel Contento suggests that we should be teaching people to understand the "energy costs, ecological consequences, and moral implications of their food choices; to analyze the impact of the food system on society as a whole; and to act self-reliantly in providing nourishing meals for themselves and others." In view of the contrast between a third world in which starvation is rampant, and the domestic scene in which the aluminum container for a 1-kcalorie diet soda costs 400 kcalories to produce, perhaps our awareness does indeed need to be raised.

Estimating kCalorie Output by the Body

Counting the kcalories in your food tells you your energy income, but to balance your budget you also need to know your expenditure. How can you count the kcalories you expend in a day? One way is to assume you are a "typical citizen" of the United States or Canada, and to use the numbers their governments use as standards for population studies.

Government Recommendations

The U.S. Committee on RDA and the Canadian Ministry of Health and Welfare have published recommended energy intakes for various age-sex groups in their populations. These are useful for population studies, but the range of energy needs for any one group is so broad that it is impossible even to guess an individual's need from them without knowing something about the person's lifestyle. The U.S. recommendation for a woman, for example, assumes she is 20 years old, 5 feet 4 inches tall, weighs about 120 pounds, and typically engages in light activity. A woman who fits all these descriptors is said to need between 1,700 and 2,500 kcalories a day to maintain her weight. The man used, as a reference figure is 20 years old, 5 feet 10 inches tall, weighs 154 pounds, engages in light activity, and need 2,500 to 3,300 kcalories a day. Taller people need proportionately more and shorter people proportionately fewer, kcalories to balance their energy budgets. Older people generally need fewer kcalories, with the number diminishing about 5 percent per decade beyond 30. Light activity, for both women and men, means sleeping or lying down for eight hours a day, sitting for seven hours, standing for five, walking for two, and spending two hours a day in light physical activity.

Although very few people fit these descriptions exactly, most fall close to the mean. The total span of needs is broad. For adults it is believed that an 800-kcalorie range covers most individuals, but some have energy needs outside this range. Clearly, it is impossible to pinpoint any person's energy need within such a wide range without knowing more.

530 Kcalorie Meal

1 c milk (80) plus 2 fat (90)	170 kcal
½ c beans	25
1 small potato (1 starchy vegetable)	70
1 pat butter (1 fat)	45
4 oz fish (4 lean meat, assuming no fat is added), at 55 kcal/oz	220
Lemon wedge	0
TOTAL KCAL:	**530 kcal**

Diet Record Method

To obtain an individualized estimate of your energy needs, the best means would be to monitor your food intake and body weight over a period of time in which your activities are typical of your lifestyle. If you keep a strictly accurate record of all the food and beverages you consume for a week or two, and if your weight does not change during that time, you can assume that your energy budget is balanced. Records have to be kept for at least a week, however, because intakes fluctuate from day to day. (On about half the days you eat less, on the other half more, kcalories than the average.) If during a week you gain a pound of fat, you can deduce that you expended 3,500 kcalories less than you consumed, or an average of 500 kcalories per day for the seven days.

Energy Balance: Weight Loss and Gain

In the average person, a deficit of 500 kcalories a day brings about loss of body fat at the rate of a pound a week; of 1,000 kcalories, two pounds a week. Extraordinarily active people, by virtue of their high-energy expenditures, or extremely obese persons, by virtue of the metabolic demands made by the sheer bulk of their body cells and the energy cost of moving their bodies, can lose weight faster. For those who are only moderately obese, the maximum possible rate of fat loss is one to two pounds a week, which for most people means an intake of about 1,000 to 1,500 kcalories a day. Below 1,200, the dieter will be losing lean tissue, and at such a restricted kcalorie level, the diet planner is hard put to achieve adequacy for all the vitamins and minerals. (The person of below-average height will need to adjust these numbers in proportion to his or her height.)

These principles are simple, but putting them into practice is more difficult than you might imagine. Obesity and underweight are complex problems with social and psychological ramifications, as well as the metabolic ones just described. The next session deals with the factors that contribute to the problems of overweight and underweight and then provides some practical pointers for the person who wants to lose or gain weight.

CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 6 **– QUESTION & ANSWERS**

NAME: ______________________________

ADDRESS: ______________________________

PHONE: ______________________________

FAX: ______________________________

E-MAIL: ______________________________

Please be sure to fill out the information above, complete the test and e-mail or fax it back to us at iridology@netzero.net or 425-955-4639. We will grade your question & answer session and will let you know if we have any questions or concerns.

1. Why should people who consume a high-protein diet drink more water?

2. Why does the person with liver disease have high blood ammonia while the person with kidney disease has high blood urea?

3. What is ketosis?

4. What is a kcalorie?

5. How many kcalories are in a meal consisting of 1 baked potato, 1 pat of butter, 1 glass of whole milk, 1 fish fillet, 1 portion of green beans, and 1 slice of lemon?

6. Keep an individualized estimate of your energy needs; the best means would be to monitor your food intake and body weight over a period of time in which your activities are typical of your lifestyle. If you keep a strictly accurate record of all the food and beverages you consume for a week or two, and if your weight does not change during that time, you can assume that your energy budget is balanced. Share with us what you found out about your energy needs. Everything is held strictly confidential.