CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 8:

- **The Water-Soluble Vitamins: B Vitamins and Vitamin C**

A television commercial broadcast widely some years ago shows a middle-aged businessman shuffling weakly out of his bedroom with his bathrobe slung loosely around his sagging paunch. He sinks into his chair at the breakfast table and wearily lifts the morning paper to screen his face from the daylight and from his bright-eyed, energetic wife. As she placed his coffee cup before him, she observes sympathetically, “Sweetie, you look so tired. Did you forget to take your vitamin pill today?” (Fadeout, with the voice of the announcer saying, “Are you tired in the morning? Do you hate to face the day? What you need is Brand A Vitamins.”) Repeat: The same man, transformed, trim and bouncy, waltzes into the breakfast nook, pirouettes gaily around the tables, kisses his wife affectionately, takes two hasty sips of coffee, and strides humming out the door. She turns cheerfully to the camera and smiles, “Brand A Vitamins have done wonders for my Harry.”

True? No. Poor Harry. If he tries to live on only coffee and vitamins, he will remain a wreck. Like all organic nutrients found in foods, the B vitamins are composed of carbon, hydrogen, oxygen, and other atoms linked together by chemical bonds. Of course, these bonds contain energy, but that energy cannot be used to fuel activities or to do the body’s work. The energy Harry needs comes from carbohydrate, fat, and protein; the vitamins will only help him burn the fuel if he has the fuel to burn.

It is true; however, that without B vitamins you would certainly feel tired. You would lack energy. Why is this? Some of the B vitamins serve as helpers to the enzymes that release energy from the three energy nutrients – carbohydrate, fat, and protein. The B vitamins stand alongside the metabolic pathways and help to keep the disassembly lines moving. In an industrial plant they would be called expediters. Some of them help manufacture the red blood cells, which carry oxygen to the body’s tissues; the oxygen must be present for oxidation and energy release to occur.

So long as B vitamins are present, their presence is not felt. Only when they are missing does their absence manifest itself as a lack of energy. A child who learned this defined vitamins on a test as “what if you don’t eat you get sick.” The definition is one of the most insightful we’ve seen.

Water-Soluble Vitamins

The B vitamins and vitamin C are entitled to individual attention, but the whole array of them is presented here first to show you the “forest” in which they are the trees. They come together in foods, they work together in the body, and there is much to be learned from viewing them as a group.

First of all, together with vitamin C, the B vitamins form a natural group of nutrients known as the water-soluble vitamins. They are present in the watery compartment of foods, and they distribute into the water-filled compartments of the body. They can easily be excreted in the urine if their blood concentration rises too high – in contrast to the fat-soluble vitamins, which tend to be hidden away in storage places. As a consequence, the water-soluble vitamins are less likely to reach toxic levels (a plus), but are also more easily depleted (a minus), than the fat-soluble vitamins.

Caution:

The B vitamin riboflavin is a yellow compound so bright that it is easy to see in a water solution. Since excesses of the B vitamin are excreted, bright yellow urine may signify the presence of this vitamin. If you are in the habit of taking a multivitamin supplement “to avoid deficiencies” and your diet is otherwise adequate in riboflavin, you may notice this effect.

Some vitamin supplements are inexpensive, but others are absurdly costly. Most people do need them. As you read on, you may discover that it is easy to make your diet adequate by eating nutritious foods alone. If you do consume an adequate diet, the following statement may apply to you. Overdosing with B vitamins will do nothing for you but increase the dollar value of your urine.

In summary, the water-soluble vitamins are:

- Carried in the bloodstream.
- Excreted in urine.
- Needed in frequent small doses.
- Unlikely to be toxic.

The B Vitamins: Coenzymes

Each of the B vitamins is part of an enzyme helper known as a coenzyme. A coenzyme is a small nonprotein molecule that associates closely with an enzyme. Some coenzymes form part of the enzyme structure, in which case they are known as prosthetic groups; others are associated more loosely with the enzymes. Some participate in the reaction being performed and are chemically altered in the process, but they are always regenerated sooner or later. Others are unaltered but form part of the active site of the enzymes. Thus although there are differences in details, one thing is true of all. Without the coenzymes, the enzymes cannot function.

The consequences of a failure of metabolic enzymes can be catastrophic, as you will realize if you study the central pathway of metabolism by which glucose is broken down. The nicknames for some of the coenzymes that keep the processes going (NAD+, TPP, FAD, and CoA) are listed beside the reactions they facilitate; the vitamin names are given below.

B-Vitamin Terminology

Many of the vitamins have both names and numbers, a mixture of terminologies that confuses newcomers to the study of nutrition. As of 1979, a single set of names for the vitamins had been agreed on and was published, and those names are used in this course. Still, to read the many worthwhile writings published prior to 1979, you have to be aware of the alternative names:

Correct Name	Other Names Commonly Used
Thiamin	Vitamin B_1
Riboflavin	Vitamin B_2
Niacin	Nicotinic acid, nicotinamide, niacinamide
Vitamin B_6	Pyridoxine, pyridoxal, pyridoxamine
Folacin	Folate, folic acid
Vitamin B_{12}	Cobalamin
Pantothenic acid	(None)
Biotin	(None)

Look at the first step. Some of the enzymes involved in the breakdown of glucose to pyruvate require the coenzyme NAD+. Part of this molecule is a structure the body cannot make. Hence it must be obtained from the diet; it is an essential nutrient (Session 1).

In other words, to take glucose apart the cells must have certain enzymes. For the enzymes to work, they must have the coenzymes NAD+. To make NAD+, the cells must be supplied with niacin (or a closely related compound they can alter to make niacin). The rest of the coenzyme they can make without outside help.

The next step in glucose catabolism is the breakdown of pyruvate to Acetyl-CoA. The enzymes involved in this step require NAD+ plus another coenzyme, TPP. The cells can manufacture the TPP they need from thiamin, but thiamin is a compound they cannot synthesize; so it must be supplied in the diet. Thiamin is the vitamin part.

Another coenzyme needed for this step is coenzyme A, or CoA for short. As you have probably guessed, the cells can make CoA except for an essential part of it that must be obtained in the diet. This essential part – the vitamin part – is pantothenic acid.

The next step in glucose catabolism is breakdown of Acetyl-CoA to carbon dioxide. The enzymes involved in this process require two of the three coenzymes mentioned above – NAD+ and coenzyme A – and, in addition, another – FAD. Again, FAD is synthesized in the body, but part of its structure, the vitamin riboflavin, must be obtained in the diet.

Now suppose the body’s cells lack one of these B vitamins – niacin, for example. Without niacin, the cells cannot make NAD+. Without NAD+, the enzymes involved in every step of the glucose-to-energy pathway will fail to function. Since it is from these steps that energy is made available for all the body’s activities, everything will begin to grind to a halt. This is no exaggeration. The symptoms of niacin deficiency are the devastating “four Ds”: dermatitis, which reflects a failure of the skin to maintain itself; dementia (insanity), a failure of the nervous system; diarrhea, a failure of digestion and absorption; and death. These are only the most obvious, observable symptoms. Every organ in the body, being dependent on the energy pathways, is profoundly affected by niacin deficiency. As you can see, niacin is a little like the horseshoe nail for want of which a war was lost.

Mother Goose
For want of a nail, a horseshoe was lost.
For want of a horseshoe, a horse was lost.
For want of a horse, a soldier was lost.
For want of a soldier, a battle was lost.
For want of a battle, the war was lost,
And all for the want of a horseshoe nail!

The complete breakdown of amino acids and fat, as well as that of glucose, depends on the coenzymes just described. You may remember that a major product of the breakdown of amino acids and fat is Acetyl-CoA and that this product is processed in exactly the same way as the Acetyl-CoA from glucose. Thus the release of energy from all foods depends on the same vitamins.

Not only the breakdown (catabolism) but also the building (anabolism) of compounds in the body requires coenzymes. For example, one step in the manufacture of a nonessential amino acid is the step in which the nitrogen-containing amino group is attached to a carbon skeleton – a process called transamination. Enzymes performing this function require a coenzyme made from the essential nutrient vitamin B6.

Two other B vitamins – Folacin and vitamin B_{12} – are together involved in building the units that form part of DNA. Folacin aids directly in the synthesis of one of the purines, and vitamin B_{12} indirectly in the synthesis of the Folacin coenzymes. Whenever a cell divides, it must make a whole new copy of its DNA; thus these two coenzymes are necessary for making all new cells. They also serve other functions.

Finally, biotin, another B vitamin, serves as a helper in many reactions in which single-carbon groups are shifted from one structure to another. Many reactions involve this activity, including those of fatty acid synthesis and the reaction that converts pyruvate into a compound used in the TCA cycle.

In summary, these eight B vitamins play many specific roles in helping the enzymes to perform thousands of different molecular conversions in the body. They are active in carbohydrate, fat and protein metabolism and in the making of DNA and thus new cells. They are found in every cell and must be present continuously for the cells to function, as they should. It must now be abundantly clear why poor Harry needs the B vitamins to make him feel well, even though without food they do nothing for him. No matter what he eats, he needs B vitamins to help him process it.

Coenzyme (co-EN-zime)
A coenzyme is a small molecule that works with an enzyme to promote the enzyme's activity. Many coenzymes have B vitamins as part of their structure.
Co = with

Prosthetic (pros-THET-ic) Group
A prosthetic group is a coenzyme that is physically part of (attached to) its enzyme.
Prosth = in addition to

Active Site
An active site is that part of the enzyme surface on which the reaction takes place.

Niacin (NIGH-uh-sin)
Niacin is a B vitamin. Niacin can be eaten preformed or can be made in the body from tryptophan, one of the amino acids.

Precursor
A precursor is a compound that can be converted to a nutrient in the body. Thus tryptophan is a precursor of niacin.

Thiamin (THIGH-uh-min)
Thiamin is a B vitamin.

Pantothenic (PAN-to-THEN-ic) Acid
Pantothenic Acid is a B vitamin.

Riboflavin (RIBE-o-flay-vin)
Riboflavin is a B vitamin.

Transamination

Transamination is the transfer of an amino group from one compound to another, as when nonessential amino acids are manufactured in the body.

Vitamin B_6

Vitamin B_6 is a family of compounds – pyridoxine, pyridoxal, and pyridoxamine – that act as part of the coenzymes in amino acid metabolism. The step that begins the breakdown of stored glycogen to glucose also depends on these coenzymes; and a crucial step in the making of the iron-containing portion of hemoglobin for red blood cells does, too.

Folacin (FOLL-uh-sin)

Folacin is a B vitamin that acts as part of the coenzyme in the manufacture of new DNA and new cells; it transfers single-carbon groups.

Vitamin B_{12}

Vitamin B_{12} is a vitamin whose coenzyme helps make the active forms of Folacin.

Biotin (BY-o-tin)

Biotin is a B vitamin, a coenzyme involved in shifting single-carbon (CO2) groups, necessary for fat synthesis and other metabolic reactions. The TCA cycle intermediate produced with the help of biotin is oxaloacetate.

B Vitamins and Prescription Drugs

Like the coenzymes, drugs are small but potent molecules and they often work in the body by altering the actions of its proteins. However, although the body is equipped by eons of evolutionary time to accommodate the vitamins and to use them appropriately, it has had no such long experience with drugs. Most of the prescription drugs are new compounds, synthesized in the laboratory, which affect body functions in ways that may be useful to fight disease. But many drugs have side effects. While they work in one area to counteract the disease process or to correct an abnormality, they may also work in other areas to interfere with normal body processes. Sometimes they interfere with the action of the B vitamins.

For example, a potent drug that inhibits the growth of the tuberculosis bacterium, nicknamed INH, has saved countless lives because of its efficacy against tuberculosis. But INH is also a vitamin B_6 antagonist; it binds and inactivates the vitamin, inducing a deficiency. Whenever INH is used to treat tuberculosis, supplements of vitamin B_6 must be given to protect the patient from deficiency.

Another example is aspirin, the most frequently prescribed pain reliever. It is very effective against pain, but it also interferes with the binding of Folacin to carrier proteins and increases Folacin excretion. (It has an impact on vitamin C and iron nutrition, too.) This doesn't imply that aspirin should never be used but rather that people using drugs and physicians prescribing them should be aware that they might affect nutrition.

<u>Caution:</u>
It is important for someone new to the study of nutrition to be reminded at this point that this is a course about healthy people. The nutrient needs of people who are ill or who are using large amounts of drugs – including nonprescription drugs like alcohol – are not discussed here. Nor are the special needs of people with inborn genetic defects that may greatly increase their individual needs for certain nutrients. The statements about recommended intakes and about foods that provide the recommended amounts apply to most people, normally, but there are exceptions that are outside our province.

B-Vitamin Deficiency

Removing a number of "horseshoe nails" can have such disastrous and far-reaching effects that it is difficult to imagine or predict the results. Oddly enough, although we know a great deal about their individual molecular functions, we are unable to say precisely why a deficiency of one B vitamin produces the disease beriberi whereas the deficiency of another produces pellagra. We do know, however, that with the deficiency of any B vitamin, many body systems become deranged, and similar symptoms may appear.

A deficiency of any one B vitamin seldom shows up in isolation. After all, people do not eat nutrients singly; they eat foods, which contain mixtures of nutrients. If a major class of foods is missing from the diet, the nutrients contributed by that class of foods would all be lacking to varying extents. In only two cases, dietary deficiencies associated with single B vitamins have been observed on a large scale in human populations, and diseases have been named for them. One of these diseases, beriberi, was first observed in the Far East when the custom of polishing rice became widespread. Rice contributed 80 percent of the kcalories consumed by the people of those areas, and rice hulls were their principal source of thiamin. When the hulls were removed, beriberi spread like wildfire. It was believed to be an epidemic, and medical researchers wasted much time and energy seeking a microbial cause before they realized that the problem was not what was present in the food but what was absent from it.

The other disease, pellagra, became widespread in the U.S. South in the early part of this century, in people who subsisted on a low-protein diet whose staple grain was corn. This diet was unusual in that it supplied neither enough niacin nor enough of its amino acid precursor tryptophan to make up the deficiency.

Even in these cases, the deficiencies were not pure. When foods were provided containing the one vitamin known to be needed, the other vitamins that may have been in short supply came as part of the package

Beriberi

Beriberi is the thiamin-deficiency disease which pointed the way to discovery of the first vitamin, thiamin.

Pellagra (pell-AY-gra)

Pellagra is the niacin-deficiency disease.
Pellis = skin
Agra = seizure

Once vitamin research was well under way and other B vitamins had been discovered, the clarification of their function was often greatly helped by laboratory experiments in which animals or human volunteers were fed diets devoid of one vitamin. The effect of the deficiency of that vitamin could then be studied to determine what functions it normally performed. Other deficiency diseases were discovered in this way and have since been observed to occur outside the laboratory.

The following table sums up a few of the better-established facts about B vitamin deficiencies. A look at the table will make another generalization possible. Different body systems depend to different extends on these vitamins. Processes in nerves and in their responding tissues, the muscles, depend heavily on glucose metabolism and hence on thiamin; thus paralysis sets in when this nutrient is lacking. The replacement of red blood cells and GI tract cells occurs at a rapid pace and involves much making of DNA; the making of new cells depends on a Folacin coenzymes and the making of this coenzyme depends on vitamin B_{12}, so two of the first symptoms of a deficiency of either of these nutrients are a type of anemia and GI deterioration. But again, each nutrient is important in all systems, and these lists of symptoms are far from complete.

The skin and the tongue appear to be especially sensitive to vitamin B deficiencies, but you should not that the listing of these items in the table gives them undue emphasis. Remember that in a medical examination these are two body parts that are visible. If the skin is degenerating, other tissues beneath it may be, too. Similarly, the mouth and tongue are the visible part of the digestive system; if they are abnormal, there may well be an abnormality throughout the GI tract. What is really happening in the vitamin deficiency happens inside the cells of the body; what the doctor sees and reports are its outward manifestations.

Caution:

It is more and more apparent that you cannot observe a symptom and automatically jump to a conclusion regarding its cause. The warning was given earlier (in Session 3) that skin rashes are a symptom, not a disease. As you have seen, deficiencies of linoleic acid, riboflavin, niacin, and vitamin B_6 can all cause rashes. A deficiency of vitamin A can, too. Because skin is on the outside, where you and your doctor can easily look at it, it is a useful indicator of things-going-wrong-in-cells. But by itself a skin symptom tells you nothing about its possible cause.

The same is true of anemia. We often think of anemia as being caused by an iron deficiency, and often it is. But anemia can also be caused by a Folacin or vitamin B12 deficiency, by digestive tract failure to absorb any of these nutrients, or by such nonnutritional causes as infections, parasites, cancer, or loss of blood. So be careful. You can often recognize a false claim by the implication that a specific nutrient will always cure a given symptom.

A person who feels chronically tired may be tempted to diagnose herself as having anemia. Knowing only enough to associate iron deficiency with this condition, she may decide to take an iron supplement. But the iron supplement will relieve here tiredness only if the symptom is caused by iron-deficiency anemia. If she has a Folacin deficiency (and Folacin deficiency is probably the most widespread vitamin deficiency in the world), taking iron will only prolong the period in which she receives no relief. If she is better informed, she may decide to take a vitamin supplement with iron, covering the possibility of a vitamin deficiency. But now she is forgetting that there may be a nonnutritional cause of her symptom. If the cause of her tiredness is actually hidden blood loss due to cancer, the postponement of a diagnosis may be equivalent to suicide.

Deficiency Syndrome

Vitamin	Disease	Area Affected	Main Effects	Technical Terms
Thiamin	Beriberi	Nervous system Muscles Cardiovascular System	Mental confusion Peripheral paralysis Weakness Wasting Painful calf muscles Edema Enlarged heart Death from cardiac failure	
Riboflavin	Ariboflavinosis	Facial skin Eyes	Dermatitis around nose and lips Cracking of corners of mouth Hypersensitivity to light Reddening of cornea	Cheilosis kee-LOH-sis Photophobia
Niacin	Pellagra	Skin Tongue GI Tract Nervous system	Bilateral symmetrical dermatitis, especially on body parts exposed to sun Loss of surface features, selling, edema Diarrhea Irritability Mental confusion, progressing to psychosis or delirium	 Glossitis gloss-EYE-tis
Vitamin B_6	(No name)	Skin Tongue Nervous system	Dermatitis Cracking of corners of mouth Irritation of sweat glands Smoothness-atrophy of surface structures Abnormal brain wave pattern Convulsions	 Cheilosis Glossitis
Folacin	(No name)	Tongue GI Tract Blood	Smoothness, swelling, cracks Diarrhea Anemia (characterized by large cells)	Glossitis Macrocytic anemia
Vitamin B_{12}	Pernicious anemia	Blood Nervous system	Anemia (characterized by large cells) Degeneration of peripheral nerves	Macrocytic anemia
Pantothenic Acid	(No name)	GI Tract Nervous system	Vomiting, GI distress Insomnia, fatigue	
Biotin	(No name)	Skin Nervous system GI tract Cardiovascular system	Scaly dermatitis, drying, loss of hair Depression, lassitude, muscle pains Anorexia, nausea Abnormal heart action	

Fortification
Fortification is the addition of nutrients to a food, often in amounts much larger than might be found naturally in that food.

Enrichment
Enrichment is now considered synonymous with fortification; previously, the addition of four specific nutrients – iron, thiamin, riboflavin, and niacin – to refined breads and cereals in amounts approximately equivalent to those originally present in the whole grain.

Major, epidemic-like deficiency diseases such as pellagra and beriberi are no longer seen in the United States and Canada, but lesser deficiencies of nutrients, including the B vitamins, sometimes are observed. They occur in people whose food choices are poor because of poverty, ignorance, illness, or poor health habits like alcohol abuse. They are especially likely if the staple grain food is refined, as were most bread and cereal products chosen by U.S. consumers during the 1930s and before. One way to protect these people is to add nutrients to their staple food, a process known as fortification or enrichment. The enrichment of refined breads and cereal, required by law in most Eastern states since the late 1940s and in many Western states since the early 1970s, has increased many people's iron and B-vitamin intakes.

The B Vitamins in Foods

The preceding sections have shown both the great importances of the B vitamins in promoting normal, healthy functioning of all body system and the severe consequences of deficiency. Now you may want to know how to be sure you are getting enough of these vitamin nutrients. This section offers some practical pointers regarding food intake.

Thiamin

The recommended daily thiamin intake for adults is about 1.5 milligrams for men and about 1.0 for women (plus an extra half-milligram during pregnancy). Infants require about half a milligram and children about three-fourths.

Riboflavin

The recommended daily riboflavin intake for adults is about 1.4 to 1.8 milligrams for men and about 1.1 to 1.3 for women (plus about 0.3 milligrams during pregnancy), depending on how much energy they expend daily. (Like thiamin, riboflavin needs can be stated in terms of milligrams per 1,000 kcalories.) Young children's needs begin at about 1 milligram a day and rise rapidly during their growing years. Teenagers, because they are very active, need more riboflavin than adults do.

Niacin

Recommended niacin intakes are stated in "equivalents," a term that requires explanation. Niacin is unique among the B vitamins because it can be obtained from another nutrient source – protein. The amino acid tryptophan can be converted to niacin in the body: 60 milligrams of tryptophan yields 1 milligram of niacin. Thus a food containing 1 milligram of niacin and 60 milligrams of tryptophan contains the equivalent of 2 milligrams of niacin, or 2-milligram equivalents.

Recommended daily intakes for men are about 15 to 20-milligram equivalents and for women about 12 to 15 (plus 2 to 5 milligram equivalents during pregnancy and lactation). Infants', children's, and teenagers' needs are proportional not to their size but to their energy output.

To obtain a rough approximation of your niacin intake:

1. Calculate total protein consumes (g).
2. Subtract your recommended protein intake to obtain "leftover" protein usable to make niacin (g).
3. Divide by 100 to obtain the amount of tryptophan in this protein (g).
4. Multiply by 1,000 to express this amount of tryptophan in milligrams (mg).
5. Divide by 60 to get niacin equivalents (mg).
6. Finally, add the amount of niacin obtained preformed in the diet (mg).

Vitamin B_6

Because the vitamin B_6 coenzymes play many roles in amino acid metabolism, dietary needs are roughly proportional to protein intakes. Adults need about 2 milligrams a day; this is enough to handle 100 grams of protein. Pregnant and lactating women need about half a milligram more. Infants probably receive enough vitamin B_6 either from breast milk or cows milk formula. There is some possibility that older people have a greater need for vitamin B_6 than young adults do.

Folacin

Folacin occurs in foods in both bound and free forms; the free form is better absorbed. The U.S. recommendation for adults is stated in terms of all forms of Folacin and is 400 micrograms a day. The need for Folacin rises dramatically during pregnancy, more than the need for any other nutrient; the RDA table doubles the Folacin recommendation to 800 micrograms a day during pregnancy.

Vitamin B_{12}

According to the U.S. recommendations, adults need about 3 micrograms of vitamin B_{12} a day (plus 1 microgram during pregnancy).

Pantothenic Acid and Biotin

The six best-known B vitamins have already been discussed. Two other B vitamins – pantothenic acid and biotin – are needed for the synthesis of coenzymes that are active in a multitude of body systems. These are just as important as the vitamins discussed so far, but both pantothenic acid and biotin are widespread in foods, and there seems to be no danger that people who consume a variety of foods will suffer deficiencies.

Non-B Vitamins

Trios of compounds sometimes called B vitamins are inositol, choline, and lipoic acid. These are not essential nutrients for humans, although deficiencies can be induced in laboratory animals in order to study their functions. Like the B vitamins described above, they serve as coenzymes in metabolism, Even if they were essential for humans, supplements would be unnecessary, because they are abundant in foods.

When used as drugs, choline and its relative lecithin have some important beneficial effects on several disease conditions that affect memory and muscular coordination. These particular diseases are responsive, not because they are caused by deficiencies of choline or lecithin, but because large doses of these nutrients act in a different way altogether from normal doses.

The beneficial effects of choline and lecithin on these diseases have led to many false claims – "Lecithin improves memory" and the like – with a consequent rush to buy and consume bottles of it. As a result, medical practitioners have been able to witness and report on the effects of over-doses of these compounds. They can cause not only short-term discomforts such as GI distress, sweating, salivation, and anorexia, but also long-term health hazards from disturbance of the nervous and cardiovascular systems.

Caution:

If you read or hear a report of a substance having a beneficial or harmful effect, it is an oversimplification to conclude that the substance is "good" or "bad." You must ask what dose was used. Two corollaries to this statement must be the following:

- A substance that is poisonous at a high concentration may be an essential nutrient at a lower concentration.
- A nutrient needed at a low concentration may be toxic at a high concentration.

In addition to choline, inositol, and lipoic acid, other substances have been mistaken for essential nutrients for humans because they are needed for growth by bacteria or other forms of life. These substances include:

- PABA (para-aminobenzoic acid).
- Ubiquinone

Other names you may hear are "Vitamin B_5" (another name for pantothenic acid), "Vitamin B_{15}" (a hoax), "Vitamin B_{17}" (laetrile and not a vitamin), "Vitamin B_T" (carnitine, an important piece of cell machinery but not a vitamin), and more. There is another water-soluble vitamin, however, of great interest and importance – vitamin C.

Vitamin C

Two hundred years ago, any man who joined the crew of a seagoing ship knew he had only half a chance of returning alive – not because he might be slain by pirates or die in a storm but because he might contract the dread disease scurvy. As many as two-thirds of a ship'' men might die of scurvy on a long voyage. Only ships that sailed on short voyages, especially around the Mediterranean Sea, were safe from this disease. It was not known at the time that the special hazard of long ocean voyages was that the ship's cook used up his provisions of fresh fruits and vegetables early and relied for the duration of the voyage on cereals and live animals brought along as provisions.

The first nutrition experiment conducted on human beings was devised in 1747 to find a cure for scurvy. Dr. James Lind, a British physician, divided 12 sailors with scurvy into six pairs. Each pair received a different supplemental ration: vinegar, sulfuric acid, seawater, orange, lemon, or none. The ones receiving the citrus fruits were cured within a short time. Sadly, it was 50 years before the British Navy made use of Lind's experiment by requiring all vessels to carry sufficient limes for every sailor to have limejuice daily. British sailors were still nicknamed "limeys" as a result of this tradition.

The antiscurvy "something" in limes and other foods was dubbed the antiscorbutic factor. Nearly 200 years later, the factor was isolated from lemon juice and found to be a six-carbon compound similar to glucose. It was named ascorbic acid. Shortly thereafter it was synthesized, and today hundreds of millions of vitamin C pills are produced in pharmaceutical laboratories each year and sold for a few dollars a bottle.

Human needs for vitamin C are the subject of much disagreement among experts. The publication of Linus Pauling's controversial book Vitamin C and the Common Cold thrust this vitamin into the limelight in 1970 and persuaded thousands of readers that they should be taking does much higher than the 45 or 60 milligrams a day cited as adequate in published recommended intakes. Highly respected nutritionists and other scientists have taken positions at both extremes on this issue. The controversy over the common cold has largely died down in the popular press, but the question of how much is enough is still being hotly debated.

There is also a controversy over the risks of taking large doses of vitamin C. Some argue for megadoses on the grounds that the risks of excess are negligible but the risk of deficiency are great. Others argue against megadoses because the risk of deficiency is negligible but the risks of toxicity are great! Both positions are based on reasoning from small amounts of evidence and large numbers of words.

We face a difficult task in trying to sort out what is known about vitamin C, what is likely to be shown true, and what claims are clearly unfounded.

Scurvy

Scurvy is the vitamin C deficiency disease.

Antiscorbutic Factor

The antiscorbutic factor is the original name for vitamin C.
Anti = against
Scorbutic = causing scurvy

Ascorbic Acid

Ascorbic Acid is one of the two active forms of vitamin C. Many people consistently (and incorrectly) refer to all vitamin C by this name.
A = without
Scorbic = having scurvy

Megadoses

Doses of 10 to 30 or more times the recommended intake of a nutrient are termed megadoses. In the case of vitamin C, any amount of 1-g (1,000-mg) is considered a megadose.

Metabolic Roles of Vitamin C

Vitamin C is a mysterious vitamin. Like all the vitamins, it is a small organic compound needed by human beings in minute amounts daily. Being organic, it is convertible to several different forms, two of, which are active. Like the B vitamins, it is water-soluble, and so it is excreted rapidly when excesses are taken. But unlike the B vitamins (which for the most part have clearly defined roles as coenzymes), vitamin C acts in ways that are imperfectly understood. It plays many different important roles in the body, and the secret may be that its mode of action is different in each case. In some settings it may act as a coenzyme or cofactor, assisting a specific enzyme in the performance of its job. In others, it may act in a more general way – for example, as an antioxidant. Often the conclusion reached by investigators studying vitamin C is that it has to "be present" for certain reactions to occur but that the mechanism of its action will require further research.

Collagen Formation

The best-understood metabolic role of vitamin C is its function in helping to form the protein collagen. Brief mention was made of this protein in Session 4; it is the single most important protein of connective tissue. It severs as the matrix on which bone is formed. It forms scars; when you have been wounded, collagen glues the separated tissue faces together. The cement that holds cells together is largely made of collagen; this function is especially important in the artery walls, which must expand and contract with each beat of the heart, and in the walls of the capillaries, which are thin and fragile and must withstand a pulse of blood every second or so without giving way.

Collagen, like all proteins, is formed by the stringing together of a chain of amino acids. An amino acid used in abundance to make collagen is proline. After proline is added to the chain, an enzyme adds an OH group to it, making hydroxyproline. This step, which completes the manufacture of collage, requires oxygen and a special form of iron – the ferrous ion. This iron has a tendency to convert to another form (ferric ion), which the enzyme can't use. Vitamin C stands by to catch ferric ions and reconvert them to the ferrous form so that the enzyme can keep on working.

Antioxidant Action

Chemists call the two forms of iron just described oxidized and reduced iron. The oxidized (ferric) form has lost three electrons; the reduced (ferrous) form has lost two. Any substance that can donate electrons to another is a reducing agent; when it donates its electrons it reduces another compound and simultaneously becomes oxidized itself. Vitamin C is such a compound.

The technicalities of oxidation-reduction reactions are not within our province, and the object of mentioning them is only to make one point clear. Many substances found in foods and important in the body can be altered or even destroyed by oxidation. (An example in Session 3 was oils that turn rancid when exposed to air.)

Vitamin C - because it can be oxidized itself -—can protect other substances from this destruction. Vitamin C is like a bodyguard for oxidizable substances; it stands ready to sacrifice its own life to save theirs. Unemotionally, the chemists call such a bodyguard an antioxidant.

Because of its antioxidant property, vitamin C is sometimes added to food products, not only to improve their nutritional value but also to protect important constituents from oxidation. In the intestines, its protects ferrous iron in this way. In the cells and body fluids, it probably helps to protect other molecules – including the fat-soluble compounds vitamin A, vitamin E, and the polyunsaturated fatty acids – by maintaining their watery neighborhood in the appropriately reduced state. Vitamin E and the polyunsaturated fatty acids are important constituents of cell membranes, and these membranes house much of the cells' machinery. This machinery must be meticulously maintained so that the cells can live and work and so that they will discriminate successfully among the things that should cross their membranes and those that should be excluded. Vitamin C – perhaps by way of its ability to alternate between the oxidized and the reduced state – helps maintain these vital functions.

The Absorption of Iron

Vitamin C eaten at the same time as iron helps to promote the absorption of the iron. It is not yet known how the vitamin performs this service, but one intriguing possibility is entitled to an explanation.

You can pick up a screw with a screwdriver – unless the screwdriver is magnetic. Even then, the screw may fall off at the slightest jolt. You can pick up a screw with a pair of pliers, but then you have to hold it tightly or it will fall out of their grip. But if you have a magnetic pair of pliers, you can hold the screw so securely that the only problem may be that you can't let it go. A chelating agent is the molecular equivalent of a magnetized pair of pliers, and vitamin C is an outstanding example of such a molecule. These molecules are especially good at holding onto positive ions such as ferrous iron. Vitamin C can grab and hold such an ion because it has two negative arms. Thus vitamin C can not only reduce iron but can also surround it. The resulting complex is more easily absorbed by the intestinal cells than iron alone.

It is now well known that eating foods containing vitamin C at the same meal with foods containing iron can double or triple the absorption of iron from those foods. This strategy is highly recommended for women and for children, whose kcalorie intakes are not large enough to guarantee that they will get enough iron from the foods they typically eat.

Amino Acid Metabolism

Vitamin C is involved in the metabolism of several amino acids. In at least some instances it probably functions as it does during collagen formation, by keeping iron in a reduced state to aid an enzyme in adding OH groups to other compounds. Some of these amino acids may end up being converted to hormones of great importance in body functioning, among them norepinephrine and thyroxin.

The adrenal glands contain a higher concentration of vitamin C than any other organ in the body, and during stress they release large quantities of the vitamin together with the stress hormones epinephrine and norepinephrine. What the vitamin has to do with the stress reaction is unclear, but it is known that stress increases vitamin C needs.

Vitamin C is also needed for the synthesis of thyroxin, which regulates the rate of metabolism. The metabolic rate speeds up under extreme stress and also when you need to produce more heat – for example, in fever or cold weather. Thus infections and exposure to cold increase your needs for vitamin C. Perhaps its involvement in the fever response to infection explains the vitamin's possible effects on cold prevention and symptom reduction.

In scurvy, protein metabolism may be altered, resulting in negative nitrogen balance. No one knows why this occurs, but the involvement of vitamin C with amino acids provides a notable example of the way nutrients of different classes cooperate with one another to maintain health.

Vitamin C Deficiency

In both the United States and Canada, vitamin C deficiency is still seen, despite the past century's explosion of nutrition knowledge. In the United States, the Ten-State Survey showed evidence of unacceptable serum levels of vitamin C in about 15 percent of all age groups studied, with symptoms of outright scurvy showing up in 4 percent. The more recent National Food Consumption Survey showed intakes below two-thirds of the RDA for 20 to 30 percent of all persons surveyed. Especially in infants, teenagers, and people of 60 years of age, intakes of vitamin C were much lower than the RDA (less than 50 percent). In Canada, many Eskimos and Indians and some members of the general population have deficiency symptoms. Evidently we all need to be alerted to the symptoms that can result and to make efforts to obtain enough of this vitamin.

With an adequate intake, the body maintains a fixed pool of vitamin C and rapidly excretes any excess in the urine. With an inadequate intake, the pool becomes depleted at a rate of about 3 percent a day. Obvious deficiency symptoms don't begin to appear until the pool has been reduced to about a fifth of its optimal size, and this may take two months or more to occur. Thus the first sign of a developing vitamin C deficiency is a lowered serum or plasma vitamin C concentration. A low intake as revealed by the diet history is the cue that prompts the diagnostician to request a clinical test to measure the body's vitamin C levels.

As the pool size continues to fall, latent scurvy appears. Two of the earliest signs have to do with the role of the vitamin in maintaining capillary integrity. The gums around teeth bleed easily, and capillaries under the skin break spontaneously producing pinpoint hemorrhages. If the vitamin levels continue to fall, the symptoms of overt scurvy appear. Failure to promote normal collagen synthesis causes further hemorrhaging. Muscles, including the heart muscle, may degenerate. The skin becomes rough, brown, scaly, and dry. Wounds fail to heal because scar tissue will not form. Bone rebuilding is not maintained; the ends of the long bones become softened, malformed, and painful, and fractures appear. The teeth may become loose in the jawbone and fillings may loosen and fall out. Anemia is frequently seen, and infections are common. There are also characteristic psychological signs, including hysteria and depression, Sudden death is likely, perhaps because of massive bleeding into the joints and body cavities.

Once diagnosed, scurvy is readily reversed by vitamin C. It can be cured within about 5 days. Moderate doses in the neighborhood of 100 milligrams per day are all that are needed.

Recommended Intakes of Vitamin C

It is important to remember that recommended allowances for vitamin C, like those for all the nutrients, are amounts intended to maintain health in healthy people, not to restore health in sick people. Unusual circumstances may increase nutrient needs. In the case of vitamin C, a variety of stresses deplete the body pool and may make intakes higher than 50 milligrams or so desirable. Among the stresses known to increase vitamin C needs are infections; burns; extremely high or low temperatures; toxic levels of heavy metals such as lead, mercury, and cadmium; and the chronic use of certain medications, including aspirin, barbiturates, and oral contraceptives. After a major operation (such as removal of a breast) or extensive burns, when a tremendous amount of scar tissue must form during healing, the amount needed may be as high as 1,000 milligrams (1 gram) a day or even more.

CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 8 **– 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. **The B vitamins serve as coenzymes assisting many enzymes in the body. T/F**

2. **Deficiency of vitamin C causes scurvy, but scurvy is prevented by the daily intake of only 5 milligrams of vitamin C and can be cured by a few days of 50-milligram doses. T/F**

3. **What are the best food sources of vitamin C?**

4. **B-vitamin deficiencies seldom occur in isolation. T/F**

5. **Riboflavin is concentrated in beans and rice. T/F**

6. **Niacin is found wherever fat is found. T/F**

7. **Vitamin C acts as an antioxidant. T/F**

8. **What is connective tissue?**

9. **What is scurvy and when was it first discovered?**

10. **What is collagen and how is it used in the body?**