BACKGROUND ON SELECTED VITAMINS, MINERALS AND ESSENTIAL FATTY ACIDS IN GLU-PRO VM AND GLU-PRO EFA

For the past 50 years, the combination of the high carbohydrate/low fat diet, food processing, depletion in soil of trace minerals, food additives, high consumption of altered and saturated fats, inactivity and stress have resulted in a rise in obesity, diabetes hyperlipidemia, and their health consequences, including cardiovascular disease (heart disease and stroke), chronic fatigue, depression, blindness (retinopathy), nerve damage (neuropathy), and kidney damage (nephropathy). Recent studies also indicate possible links between diabetes and certain forms of cancer.

Two-thirds of adults and one-third of children in this country are overweight and diabetes has become an epidemic that has increased ten-fold over the past 40 years. 24 million children and adults in the United States, (8% of the population), have diabetes, another 57 million have impaired glucose tolerance (IGT), and/or are pre-diabetic.

Diabetes is a disease in which the body does not produce or properly use insulin. Insulin is a hormone that is needed to convert sugar, starches and other food into energy needed for daily life. There are two types of diabetes:

> Type 1 diabetes -- results from the body's failure to produce insulin, the hormone that "unlocks" the cells of the body, allowing glucose to enter and fuel them. It is estimated that 10% of Americans who are diagnosed with diabetes have type 1 diabetes.
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> Type 2 diabetes -- results from insulin resistance (a condition in which the body fails to properly use insulin), combined with relative insulin deficiency. Most Americans who are diagnosed with diabetes have type 2 diabetes.

In the absence of will and desire to change life style (diet, exercise, stress management, etc.) there is a critical need to aggressively research the underlying nutritional issues and potential supplement-based solutions.

Interest in nutritional supplements for managing diabetes and diabetic-related disorders has been rapidly increasing as the link between such states and metabolic balance has been recognized in the medical community. The benefits of certain vitamins, minerals and essential fatty acids (EFAs) is generally understood as necessary for proper metabolic functioning and their effect on glucose metabolism have been either definitively established or strongly suspected.

Extensive research has resulted in the development of two patented formulas, GLU-PRO VM and GLU-PRO EFA (U.S. Patent #7,332,181 granted on February 19, 2008) that contain the vitamins, minerals and EFAs currently known or strongly suspected to be either directly or indirectly involved in glucose metabolism.

The formulas, to be taken in daily combination, were initially tailored primarily for type 1 and type 2 diabetic patients, though further scheduled research using GLU-PRO VM and GLU-PRO EFA should also show them to be beneficial to patients with hyperlipidemia, hyperinsulinism and obesity. Though not yet clinically tested, current diabetic patients and or pre-diabetic users of GLU-PRO VM and GLU-PRO EFA have consistently noted a decrease in their craving for sweets and their “carboholic” state, a reduction in weight, an increase in energy, a positive influence on their glucose metabolism, and decreased triglyceride and LDL cholesterol levels.

It is believed that these patented formulas may help inhibit or delay the onset of type 2 diabetes and assist in managing types 1 and 2 diabetes, insulin resistance states, obesity and hyperlipidemia. If proven, the regular intake of GLU-PRO VM and GLU-PRO EFA may be instrumental in decreasing the long term complications of diabetes and diabetes-related illnesses, and generally add to the users’ quality of life.

IMPORTANT NOTE: Patients with types 1 and 2 diabetes should be cautioned about the potential for hypoglycemia (low blood sugar) or other potential effects while on GLU-PRO VM and GLU-PRO EFA due to an anticipated drop in their hemoglobin A1c levels and an anticipated increase in insulin sensitivity (or decrease in insulin resistance). Patients using these supplemental formulas should consult with their physician to ensure insulin levels are appropriately adjusted (decreased), especially if combined with a decrease in their carbohydrate consumption and/or an increase in activity levels.

THE GLU-PRO VM formula contains the following vitamins.

The B Complex Vitamins
- Thiamine (vitamin B_1)
- Riboflavin (vitamin B_2)
- Niacin (vitamin B_3)
- Pantothenic Acid (B5)
- Pyridoxine (vitamin B_6)
- Biotin (vitamin B_7)
- Cobalamine (vitamin B_{12})

Vitamin D
Alpha lipoic acid
Folic acid
Vitamin C

And the following minerals.

Chromium (as chromium polynicotinate)
Vanadium (as vanadium sulfate)
Selenium
Zinc (as zinc gluconate)
Magnesium (as magnesium glycinate)
Manganese (as manganese sulfate)
Iodine
Copper (as copper gluconate)
Boron

THE GLU-PRO EFA formula contains a unique blend of 5 EFA oils combined with vitamin E and co-enzyme Q10.

The following are descriptions of the vitamins, minerals and EFAs relative to their effect on glucose metabolism:

VITAMINS USED IN GLU-PRO VM

THE B COMPLEX VITAMINS

Often used in conjunction with each other, the “family” of B vitamins are critical for normal cellular and nerve function, replication, repair, metabolism and energy production, and are critical to support proper enzymatic functions, including:

pyruvate decarboxylase (an enzyme involved in carbohydrate and fat metabolism),
propionyl-coA carboxylase (an enzyme involved in fat metabolism),
acetyl-coA carboxylase (involved in carbohydrate and fat metabolism),
branched chain alpha-keto acid dehydrogenase involved in the metabolism of some amino acids,
transketolase which acts to breakdown more complex sugars for energy production.

In people with diabetes, the water-soluble B vitamins may be lost more rapidly than in people without diabetes even if dietary intake is technically adequate. This is often due to increased urination from the osmotic effects of high blood sugar. The efficacy of the vitamins can also be easily destroyed by food processing and cooking. Therefore, supplementation of B vitamins is nearly always indicated for diabetics.

THIAMINE (Vitamin B_1)

Background. Vitamin B_1, thiamine, is necessary for metabolism of proteins, carbohydrates, and fats. Thiamine is involved as a cofactor in more than 24 enzymes, and is essential in every cell for ATP production via the Krebs cycle. It is a powerful antioxidant and protects nerve tissues against the harmful oxidization caused by alcohol, smoking and aging. It enhances circulation and assists in blood formation, carbohydrate metabolism and hydrochloric acid production, which is important for proper digestion.

Relationship to glucose metabolism and diabetic control. In a clinical trial, intravenous administration of thiamine improved functioning of the inner, endothelial lining of small arteries in patients with diabetes during induced hyperglycemia, reinforcing the role of thiamine in normal vascular function. In addition, a randomized, controlled trial of thiamine combined with pyridoxine (B_6) in patients with diabetes demonstrated significant improvements in perceived pain, numbness and paraesthesia (extra nerve sensations).

Effects of deficiency. Because thiamine is a major factor in the metabolism of glucose, it has long been known that ingestion of a high calorie, simple carbohydrate diet, processed in the body mainly to glucose, automatically increases the need for dietary thiamine, irrespective of its fortification in food substances (often referred to as “high calorie malnutrition”). Calcium and magnesium deficiency affects thiamine distribution in the liver and an imbalance of magnesium can aggravate thiamine deficiency. In recent studies, 75% of patients with diabetes were shown to have reduced levels of thiamine and increased urinary excretion of thiamine relative to controls. Antibiotics and sulfa drugs may decrease the thiamine levels in the body. Also increased metabolism due to fever, muscular activity, pregnancy, lactation, hyperthyroidism, and emotional or physical stress increases the requirement for vitamin B_1.

Dietary Source. Thiamine is present in lean pork and other meats, wheat germ, liver and other organ meats, poultry, eggs, fish, beans and peas, nuts, and whole grains. Considerable losses occur during cooking or other heat-processing of food. Polyphenolic compounds in coffee and tea can inactivate thiamine so that heavy use of these beverages could compromise thiamine nutrition.

RIBOFLAVIN (Vitamin B2)

Background. Vitamin B_2, riboflavin, is important for body growth and red blood cell production and helps in releasing energy from carbohydrates. It is not stored in the body and must be replenished daily.

Relationship to glucose metabolism and diabetic control.. In a clinical study involving diabetic and non diabetic children, the percentage of diabetic children with riboflavin deficiency was 4x greater than in non diabetics. Supplementation with daily oral riboflavin quickly returned all HgbA1C values to normal.

Effects of deficiency. Diabetic related effects of riboflavin deficiency are not definitive; however, other symptoms of significant riboflavin deficiency include sore throat, swelling of mucous membranes, mouth or lip sores, anemia, and skin disorders.

Dietary sources. Lean meats, eggs, legumes, nuts, green leafy vegetables, dairy products, and milk provide riboflavin in the diet. Breads and cereals are often fortified with riboflavin.

NIACIN (Vitamin B_3)

Background. Vitamin B_3, niacin, is important in the metabolism of carbohydrates, fats and protein and in the production of hydrochloric acid and for proper circulation of the blood and the nervous system function. Niacin opens blood vessels wider (often resulting in the normal and generally beneficial “niacin flush” effect), thus it also offers benefits in terms of blood detoxification. Studies have shown that Vitamin B_3 may be a far safer and less expensive alternative to the ingestion of cholesterol-reducing statin drugs, which may have serious complications.

Relationship to glucose metabolism and diabetic control.. High doses of niacin (as nicotinic acid) lowers cholesterol levels and appears to be most effective in newly diagnosed diabetes and in subjects with positive

islet cell antibodies that have not yet developed diabetes. People who develop type 1 diabetes after puberty appear to be more responsive to vitamin B_3 treatment. Niacin helps to preserve cell function in people with type 1 or type 2 diabetes. In studies, people with diabetes taking niacin had less progression of atherosclerosis than those taking placebo, despite poor blood glucose control, because niacin scavenges LDL ("bad") cholesterol particles while decreasing the loss of HDL ("good") cholesterol in the liver so that higher HDL levels remain in blood circulation.

Effects of deficiency. Niacin deficiency is very rare in this country due to food fortification. Diabetic related effects of riboflavin deficiency are not definitive; however a general deficiency can result in pellagra, a "raw skin" condition resulting in diarrhea, dermatitis, dementia, and death.

Dietary Sources. Good dietary sources of niacin include fortified grains, some cereals, meats, fish, and dried beans.

PANTOTHENIC ACID (Vitamin B5)

Background. Required to sustain life (essential nutrient), needed to form coenzyme-A (COA) and is critical in the metabolic and synthesis of carbohydrates, proteins and fats.

Relationship to glucose metabolism and diabetic control.. Deficiency in Pantothenic acid cause hypoglycemia or increased sensitivity to insulin. Insulin receptors are acylated with palmitic acid when they do not want to bind with insulin, therefore, more insulin will bind to receptors when acylation decreases, causing hypoglycemia. Recent research indicates that Pantathenote may help with diabetic foot healing, improve lipid profile and diabetic polyneuropathy.

Effects of deficiency.. Symptoms of deficiency include irritability, fatigue, moodiness, apathy, numbness, paresthesia and muscle cramps, restlessness, malaise, sleep disturbances, nausea, vomiting, abdominal cramps and painful burning sensation of the feet.

Dietary sources. Meats, whole grains, broccoli ad avocados, the most significant sources of pantothenic acid in nature are coldwater fish ovaries and royal jelly.

PYRIDOXINE (Vitamin B_6)

Background. Vitamin B_6, pyridoxine, is involved in hundreds of different biochemical reactions in the brain, liver, skin, joints, muscles, arteries and every other part of the body. It is also involved in the metabolism of fat, protein and carbohydrates.

Relationship to glucose metabolism and diabetic control.. Vitamin B_6 plays a role in glucose, lipid, and amino acid metabolism and neurotransmitter synthesis. The active coenzyme form of the vitamin, pyridoxal 5'phosphate, in muscle tissue is closely associated with glycogen phosphorylase.

Effects of deficiency. Deficiency of vitamin B_6 in humans and animals is associated with glucose intolerance and causes arterial damage, resulting in plaque formation.

Dietary sources. Good sources of vitamin B_6 include whole grains, animal products, and legumes.

BIOTIN (Vitamin B_7)

Background. Vitamin B_7, biotin, activates certain enzymes which aid in the metabolism of carbon dioxide and is involved in the metabolism of protein, fats and carbohydrates.

Relationship to glucose metabolism and diabetic control.. Biotin is known to bind to specific sites in enzymes involved in the metabolism of fats and carbohydrates in order to optimize function, and supplementation of biotin is known to increase the activities of these enzymes in people with diabetes as well

as those without diabetes. In people with diabetes, recent studies have demonstrated that the combination of chromium picolinate and biotin resulted in an average 0.54% reduction in HbA1c and significant reductions in LDL and VLDL cholesterol and triglycerides.

Effects of deficiency. Biotin deficiency rarely occurs among healthy people, since the daily requirement of biotin is low and many foods provide adequate amounts of it and is easily corrected through changes in diet and/or supplementation.

Dietary sources. Food sources of biotin include animal products, avocado, wheat bran, baker's yeast, raspberries, artichoke and cauliflower.

COBALAMIN (Vitamin B_{12})

Background. Cobalamin, vitamin B_{12} is essential to the production of meylin, the fatty sheath that insulates nerve fibers, keeping electrical impulses moving through the body. It is required for normal nervous system functioning and normal cell proliferation.

Relationship to glucose metabolism and diabetic control.. Vitamin B_{12} has been mostly studied in diabetes as treatment for neuropathies. In a recent systematic review, cobalamin was found to be an effective treatment for diabetic peripheral neuropathy, with pain and paraesthestias reduced the most as a result of treatment.

Effects of deficiency. Vitamin B_{12} deficiency has been linked to pernicious anemia, irritability, anorexia, listlessness, red, smooth and painful tongue, neurologic involvement is manifested by ataxia, parasthesias and hyporeflexia.

Dietary sources. Good dietary sources of vitamin B_{12} include animal foods such as seafood, beef, pork, chicken, dairy products and eggs. Vegan (non-animal) sources of B_{12} are extremely limited.

VITAMIN D

Background. . Vitamin D plays an important role in the maintenance of organ systems. Vitamin D is produced in skin exposed to sunlight, specifically ultraviolet B radiation. It regulates the calcium and phosphorus levels in the blood by promoting their absorption from food in the intestines, and by promoting re-absorption of calcium in the kidneys. It promotes bone formation and mineralization and is essential in the development of an intact and strong skeleton. Vitamin D affects the immune system by promoting phagocytosis, anti-tumor activity, and immunomodulatory functions.

Relationship to glucose metabolism and diabetic control. Data suggest that vitamin D is required for normal insulin secretion by the pancreas. Vitamin D deficiency has been linked to impaired glucose metabolism, therefore increasing the risk of type 1 diabetes. A deficiency is associated with impaired beta cell functions and insulin resistance in animals and humans and treatment of vitamin D deficiency may delay or prevent the development of insulin resistance, and thus type 2 diabetes. In a study of glucose tolerant subjects, serum 25 hydroxyvitamin D (25,OH.D) levels were associated with both insulin secretion and insulin resistance. Furthermore, researchers at the Harvard Medical School found that a study of people with low levels of vitamin D had a 62% higher risk of a cardiovascular event than those with normal vitamin D levels.

Effects of deficiency. Vitamin D. deficiency can cause rickets, osteomalcia. fatigue., bone pain and poor growth in children.

Dietary sources. Sunlight is the best source for vitamin D. Secondary sources include fortified foods (milk, dairy, cereals, margarine), mushrooms, fatty fish and eggs.

ALPHA LIPOIC ACID

Background. A vitamin-like antioxidant soluble in both fat and water, alpha lipoic acid helps convert carbohydrates to energy and is recognized as an important component of the metabolic systems. Most of the therapeutic effects of alpha lipoic acid are attributable to its antioxidant properties.

Relationship to glucose metabolism and diabetic control.. Alpha lipoic acid can improve diabetic neuropathy by reduction of the glycozilation of proteins. It also lowers insulin resistance. Alpha lipoic acid normalizes blood sugar and enhances the antioxidation power of vitamins C and E, providing extraordinary protection against free radicals. In patients with type 2 diabetes, alpha lipoic acid supplementation has been shown to improve insulin-sensitivity and oral glucose tolerance. There is also some evidence to show that alpha lipoic acid may help diabetics with cardiac autonomic neuropathy. It increases intracellular glutathione and co-enzyme Q10 levels. Alpha lipoic acid has been shown to protect against the damaging effects of oxidative stress. Under conditions of oxidative stress, what is produced in the body may not be sufficient to prevent free radical damage in the body, therefore alpha lipoic acid supplementation would certainly be of benefit. In this regard, it may be considered a "conditionally-essential" nutrient, like co-enzyme Q10.

Effects of deficiency. . Research indicates increased production of reactive oxygen species and oxidant stress is associated with type 1 and type 2 diabetes and insulin resistance. Laboratory studies show that oxidative stress can impair insulin-stimulated glucose transport and activation of insulin receptor. Data also indicate that the increased production of free radicals play an important role in the etiology of diabetic complications such as polyneuropathy.

Dietary sources. Red meat, especially heart, muscle and liver, are a relatively good source of alpha lipoic acid. Other sources include spinach, brewer's yeast and wheat germ.

FOLIC ACID

Background. Folic acid is the synthetic, and preferred supplemental, form of folate, a family of naturally occurring compounds. Folate is necessary for the production and maintenance of new cells and to synthesize the bases needed for DNA replication.

Relationship to glucose metabolism and diabetic control. Folic acid, along with vitamins B_6 and B_{12}, reduces the production of homocysteine in the blood and may be beneficial in the prevention and management of vascular complications in diabetes. Elevated homocysteine levels are believed to be responsible for up to 50% of heart attacks and strokes.

Effects of deficiency. Folate deficiency hinders DNA synthesis and cell division, affecting most notably bone marrow and cancer, both of which participate in rapid cell division.

Dietary sources. Folate is widely available in the food supply but as much as 50–95% of it may be destroyed by processing. Good dietary sources of folate include fortified grain and cereal products, brewer's yeast, spinach, orange juice, strawberries, and peanuts.

VITAMIN C

Background. Vitamin C is required for the synthesis of collagen, an important structural component of blood vessels, tendons, ligaments, and bone. In addition, vitamin C is required for the synthesis of carnitine, a small molecule that is essential for the transport of fat to cellular organelles called mitochondria, for conversion to energy. Vitamin C is also a highly effective antioxidant. Even in small amounts vitamin C can protect indispensable molecules in the body, such as proteins, lipids (fats), carbohydrates, and nucleic acids (DNA and RNA) from damage by free radicals and reactive oxygen species that can be generated during normal metabolism as well as through exposure to toxins and pollutants (e.g. smoking). Vitamin C may also be able to regenerate other antioxidants such as vitamin E.

Relationship to glucose metabolism and diabetic control. Vitamin C helps move glucose from the blood stream into the cell and aids in keeping diabetic blood vessels and kidneys healthy. One of the main benefits of extra Vitamin C is improved capillary strength. A gram of vitamin C a day brought capillary strength to nearly normal levels.

Vitamin C can elevate levels of HDL and reduce the dangerous atherosclerosis-promoting effect of LDL cholesterol by inhibiting LDL oxidation. Recent research also suggests that vitamin C is involved in the metabolism of cholesterol to bile acids, which may have implications for blood cholesterol levels and the incidence of gallstones.

Effects of deficiency.. Cardiovascular diseases (heart disease and stroke) are the leading cause of death in individuals with diabetes. Evidence that diabetes is a condition of increased oxidative stress led to the hypothesis that higher intakes of antioxidant nutrients could help decrease cardiovascular disease risk in diabetic individuals.

Dietary sources. Citrus fruits, tomatoes, berries, cabbage, green vegetables. Cooking will diminish vitamin C in food.

MINERALS USED IN GLU-PRO VM

CHROMIUM

Background. Chromium is required for the maintenance of normal glucose metabolism.

Relationship to glucose metabolism and diabetic control. . Chromium activates phoso-glucosonetase and other enzymes associated with glucose tolerance factor (GTF), which is a combination of chromium III, dinicotinic acid and glutathione. Chromium helps improve insulin's efficiency by increasing the number of insulin receptors, the binding of insulin to the receptor, and increasing activation of the insulin receptor in the presence of insulin. By transporting glucose into the cells (thereby lowering levels in the blood), chromium helps the pancreas perform better and raises HDL ("good") cholesterol levels.

Numerous researchers have investigated the effects of chromium supplements on glycemic control in types 1 and 2 diabetes, gestational diabetes, insulin resistance, reactive hypoglycemia, the elderly, and steroid-induced diabetes. Chromium has also been shown to improve various aspects of dyslipidemia in diabetic subjects.

Effects of deficiency. It is estimated that 90% of Americans are chromium deficient because of soil depletion, food processing and poor eating habits, in particular, the high carbohydrate diet. Refining whole wheat removes most of the chromium, since it is largely contained in the germ and bran and refining sugar totally depletes chromium. Very little chromium is stored in the body and a high carbohydrate diet and excessive dietary consumption of sugar will increase urinary excretion of chromium by 300% for up to 12 hours after its consumption. There is increased loss of chromium in sweat and decreased concentration by age. Experimental chromium deficiency is believed to be a causal factor in gestational diabetes and hyperglycemia and has been implicated in impaired glucose tolerance and elevated cholesterol and triglyceride levels, which improve upon the addition of chromium to the diet.

Dietary sources. Good sources of chromium include whole grains, cheese, dried beans, nuts/seeds, mushrooms, beef, wheat germ, and broccoli.

NOTE: The VM formula created for this study uses chromium polynicotonate, rather than chromium pecolonate, due to some research that links chromium pecolonate supplements to chromosome damage.

VANADIUM

Background. Vanadium is present in very minute quantities in the environment and is stored primarily in bone, transported in the bloodstream and cleared via the kidneys.

Relationship to glucose metabolism and diabetic control. . Studies on both animals and humans have proved inks between vanadium levels and normal blood glucose. It has a beneficial effect on patients with impaired glucose tolerance (hypoglycemia, hyperglycemia and hyperinsulinemia) by altering the cell membrane function for ion transport process and making the cell membrane insulin receptors more receptive to insulin. Vanadium supplementation may lead to a slight increase in sensitivity to insulin, and may therefore allow diabetic patients to decrease the amount of insulin that they need to keep their blood sugar levels under control. Vanadium stimulates glucose oxidation, metabolism, transport in fat cells and glycogen synthesis in liver and muscles. Suggested effects include inhibited hepatic (liver) gluconeogenesis (production of glucose from fat), reduced absorption of glucose from the stomach, insulin receptor autophosphorylation, increased protein tyrosine and serine threonine kinase activity, inhibition of phosphotyrosine phosphatase activity, increased adenylate cyclase activity, altered glucose-6-phosphatase activity, and increased glycogen synthesis. Vanadium enhances the stimulating effect of insulin on DNA synthesis, and it believed to inhibit cholesterol synthesis.

Effects of deficiency. An insulin mimetic, vanadium deficiency can result in elevated cholesterol, elevated triglycerides, hypoglycemia, hyperinsulinemia, and diabetes. There is a correlation between appropriate vanadium levels and adequate chromium absorption. Vanadium inhibits cholesterol synthesis in animals and in humans and is followed by decreased plasma level of cholesterol. It also has anticarcinogenic properties.

Dietary sources. Good sources of vanadium include black pepper, dill, parsley, mushrooms, spinach, oysters, shellfish, cereals, fish, and wine.

SELENIUM

Background. Selenium is a trace mineral that is essential to good health. An extremely efficient antioxidant, selenium is found at the subcellular level in the glutathione peroxidase enzyme system and the metalo amino acids. Glutathione works with vitamin E to prevent oxidative (free radical) damage to the cell membrane. Selenium prevents cellular and subcellular lipid and fat from being perioxidased (i.e., prevents body fat from going rancid). It is a versatile anticarcinogenic agent operating in several mechanisms preventing the malignant transformation of cells.

Relationship to glucose metabolism and diabetic control.. Selenium mimics insulin (insulin mimetic), helping to transport glucose into the cell and offering protection against blood vessel and nerve damage from elevated blood glucose levels.

Effects of deficiency. There is evidence to suggest that selenium deficiency may contribute to development of a form of heart disease, hypothyroidism, and a weakened immune system. There is also evidence that selenium deficiency does not usually cause illness by itself. Rather, it can make the body more susceptible to illnesses caused by other nutritional, biochemical or oxidative stresses.

Dietary sources. Plant foods are the major dietary sources of selenium in most countries throughout the world. The content of selenium in food depends on the selenium content of the soil where plants are grown or animals are raised. Brazil nuts are one of the higher sources of selenium.

ZINC

Background. Zinc helps the immune system function properly and is also needed for cell growth and division, wound healing, and the breakdown of carbohydrate for energy. Zinc is a cofactor in more than 200 enzymatic reactions, including the metabolism of nucleic acids, protein synthesis, and hormone production. Zinc is stored in the muscles, blood cells, retina of the eye, skin, bone, kidney, liver, pancreas, and in men, prostrate. Zinc is an antioxidant, protecting cells from free radicals.

Relationship to glucose metabolism and diabetic control.. Zinc is necessary for the formation of insulin in the pancreas's beta cells. Zinc helps blood glucose to get into the cell and makes insulin work better. In a recent study, blood zinc levels were lower in people who died from heart disease compared to those who survived; also, zinc levels were lower in those who had heart attacks. The study speculates that zinc supplementation may be useful in warding off heart disease in people with type 2 diabetes due it its antioxidant properties.

Effects of deficiency. Its deficiency is a worldwide problem, even among better-educated populations. Heavy losses of zinc occur in sweat and unsupplemented athletes are particularly at risk for severe zinc deficiency. Alcohol, coffee, diuretics and excesses of calcium, phosphorous, copper and iron and a high phytate (plant-based, e.g., vegan) diet interfere with zinc absorption, increases the excretion of zinc in the urine and reduce availability of dietary zinc.

Conversely, too much zinc can weaken the immune system, can lower levels of HDL cholesterol, and can cause nausea and vomiting. Selenium can also be depleted by large doses of zinc. The zinc:copper ratio must be 10:1.

Dietary sources. The main sources of zinc in diet are red meat, poultry, and seafood, but it's also found in legumes, whole grains, nuts, and dairy foods. Zinc is better absorbed from animal foods than from plant foods, since compounds called phytates that are found in plants can hinder its absorption.

MAGNESIUM

Background. Magnesium participates in more than 300 chemical reactions in the body and is a co-factor of over 100 cellular enzymatic activities. It is essential for all energy-dependent transport systems, glycolysis, oxidative energy metabolism, biosynthetic reactions, normal bone metabolism, neuromuscular activity, electrolyte balance and cell membrane stabilization.

Relationship to glucose metabolism and diabetic control. It is believed that magnesium helps insulin to work more effectively. The widespread use of magnesium in normal metabolism of macronutrients, cellular transport systems, intracellular signaling systems, platelet aggregation, vascular smooth muscle tone and contractility, electrolyte homeostasis, and phosphorylation and dephosphorylation reactions suggests that these effects are multifactorial. Clinicians believe that magnesium repletion may play a role in delaying type 2 diabetes onset and potentially in warding off its devastating complications -- cardiovascular disease, retinopathy, and nephropathy.

Effects of deficiency. It is estimated that 40% of the American population gets less than 75% of daily magnesium requirements. Magnesium's deficiency has been associated with increased insulin levels, insulin resistance, glucose intolerance, dyslipidemia, and diabetic complications. Insulin resistance has been shown to decrease magnesium uptake in type 2 diabetes. Conversely, magnesium supplementation has a mild positive effect on insulin sensitivity. Both type 1 and type 2 diabetic patients with high blood glucose levels likely have magnesium deficiencies and also lose a lot of magnesium in their urine. Asthma drugs, diuretic, digitalis and other cardiovascular medications, alcohol, caffeine and stress increases magnesium requirements and loss.

Diets low in calorie and of poor quality (high in saturated fat, fructose, caffeine, and alcohol) may increase the need for supplemental magnesium. Magnesium needs potassium and calcium to function properly. The calcium:magnesium ratio should be 2:1.

Dietary sources. Good sources of magnesium include whole grains, leafy green vegetables, legumes, nuts, and fish.

MANGANESE

Background. Manganese is essential to all known living organisms. It activates numerous enzyme systems, including those involved in glucose metabolism, energy production and superoxide dismutase and it is a major

constituent of several metalo enzymes, hormones and proteins of humans. Manganese aids in forming connective tissue, fats and cholesterol, bones, blood-clotting factors, and proteins. It is also necessary for normal brain function. Manganese is a component of manganese superoxide dismutase (MnSOD), an antioxidant that protects the body from toxic substances.

Relationship to glucose metabolism and diabetic control. Manganese activates numerous enzyme systems including those involved with glucose metabolism, energy production and super oxide dismutase. It helps prevent damage to blood vessels and nerves.

Effects of deficiency. Manganese deficiency can adversely affect fat and carbohydrate metabolism.

Dietary sources. Legumes, nuts, whole grain cereals, green leafy vegetables are good sources of manganese.

IODINE

Background. Iodine is the major component of thyroid hormones, which control and regulate digestion, heart rate, body temperature, sweat gland activity, nervous and reproductive system, general metabolism and body weight. It is believed to be an indirect yet important component of glucose metabolism.

Relationship to glucose metabolism and diabetic control. Twenty-five percent of Type I diabetics have thyroid disease. Iodine is essential for thyroid hormone production in combination with thyroxin. Copper is required to utilize iodine, therefore severe copper deficiency aggravates iodine deficiency. Selenium acts synergistically with iodine and its deficiency can affect both thyroid hormone production and iodine availability.

Effects of deficiency. Goiter and hypothyroidism have become epidemic in the United States since Americans have begun restricting their salt intake. Iodine deficiency or deprivation can affect diabetic control indirectly via hypothyroidism, affecting general metabolism and body weight. Further, normal diurnal rhythm of Cortisol secretion is lost with chronic iodine deficiency and decreased cortisol reduces the ability to respond to physiological stress.

Consumption of certain foods and food additives can cause excessive iodine loss and are goitrogeneus because they interfere with thyroid metabolism. These include nitrates (e.g., broccoli, cauliflower, cabbage, Brussels sprouts). Humans lose considerable amount of iodine in their sweat (up to 146 mcg per day with only moderate exercise).

Dietary sources. A good source of iodine is iodized salt and sea food.

COPPER

Background. Copper is essential to all living organisms and important cofactor for hundreds of metallo-enzymes. Copper is required to utilize iodine and copper deficiency aggravates iodine deficiency.

Relationship to glucose metabolism and diabetic control. . Copper helps to protect the beta cell of the pancreas, helps in preventing diabetes related damage to blood vessels and nerves and lowers blood glucose levels.

Effects of deficiency. Copper interacts with iron, so a deficiency of copper leads to anemia. An excess of zinc to copper interferes with the body ability to absorb copper, so the zinc:copper ratio must be 10:1.

Dietary sources. Liver, oysters, meats, fish, whole grains nuts and legumes are good sources of copper.

BORON

Background. Boron is a trace mineral essential for bone metabolism including efficient use of calcium and magnesium and in regulating the normal blood level of estrogen and testosterone.

Relationship to glucose metabolism and diabetic control. . A U.S. Department of Agriculture study of postmenopausal women showed that those women receiving boron supplementation have blood levels of Estradiol (estrogen) double those found in women on estrogen replacement therapy. Testosterone levels also nearly doubled. Additionally, within 8 days of supplementing boron, women lost 44% less calcium, 33% less magnesium and less phosphorous through their urine. The supplementation also activated absorption of vitamin D.

Effects of deficiency. As an ultra trace element, boron is presumed necessary for the optimal health of mammals, although it is necessary in such small amounts that ultra purified foods and dust filtration of air is necessary to show the effects of boron deficiency, which manifest as poor coat/hair quality. No deficiency syndrome in humans has been described.

Dietary sources. Small amounts of boron occur widely in the diet. Boron occurs in all foods produced from plants.

VITAMINS AND ESSENTIAL FATTY ACIDS (EFAS) USED IN GLU-PRO EFA

CO-ENZYME Q10

Background. Co-enzyme Q10 (CoQ10) is a compound that is made naturally in the body and needed for the proper functioning of enzymes and used by the cells to produce energy needed for cell growth and maintenance. It is a strong antioxidant that protects the cells from free radical damage. It stimulates the immune system, increases resistance to disease and has anticarcinogenic properties.

Relationship to glucose metabolism and diabetic control. Clinical trials using CoQ10 suggest that supplementation may significantly lower blood sugar levels. Coenzyme Q 10 also oxygenates the blood, and therefore may be able to help in some cases of diabetic retinopathy. Working together with vitamin E, CoQ10 piggybacks on LDL particles as they travel throughout the body, helping to protect them from oxidation. LDL cholesterol becomes much more dangerous to arteries once it has been oxidized, the biological equivalent of rusting. CoQ10 supplements may improve heart health and blood sugar and help manage high cholesterol and high blood pressure in individuals with diabetes. Despite some concern that CoQ10 may cause a sudden and dramatic drop in blood sugar (called hypoglycemia), two recent studies of people with diabetes given CoQ10 two times per day showed no hypoglycemic response.

Effects of deficiency. A lack of CoQ10 has been implicated in congestive heart failure and obesity, among numerous other diseases that both contribute to, and result from diabetes. Levels of CoQ10 naturally decline with age. But studies also find that cholesterol-lowering statin drugs and beta-blockers deplete CoQ10 by interfering with the body's ability to make the compound. This may be one reason for the muscle weakness sometimes associated with statins.

Dietary sources. CoQ10 can be found in red meat, nuts, dark green vegetables and vegetable oils.

VITAMIN E

Background. Vitamin E refers to a group of compounds that includes tocopherols and tocotrienols. Alpha-tocopherol is the most abundant and biologically active. This powerful, fat soluble vitamin functions primarily as an antioxidant and protects cell membranes from environmental damage and dietary and metabolic free radicals and interacts with water-soluble antioxidants such as glutathione. It also boosts the immune system's ability to fight off infections.

Relationship to glucose metabolism and diabetic control. Clinical trials involving people with diabetes have investigated the effect of Vitamin E on diabetes prevention, insulin sensitivity, glycemic control, protein glycation, micro vascular complications of diabetes, and cardiovascular disease and its risk factors. It may

play a role in preventing and treating common complications of diabetes, such as cardiovascular disease, nephropathy and neuropathy by decreasing protein glycation, lipid oxidation, and inhibition of platelet adhesion and aggregation. Vitamin E prevents the oxidation of polyunsaturated fatty acids and cholesterol by decreasing LDL cholesterol and deposits on the wall of arteries and is one of the most important in reducing probability of heart attack, stroke and atherosclerosis, to which diabetic patients are particularly susceptible.

Effects of deficiency. Low levels of vitamin E are associated with increased incidence of diabetes, and some research suggests that people with diabetes have decreased levels of antioxidants. People with diabetes may also have greater antioxidant requirements because of increased free radical production with hyperglycemia. Increased levels of oxidative stress markers have been documented in people with diabetes. Improvement in glycemic control decreases markers of oxidative stress, as does vitamin E supplementation.

Dietary sources. Good sources of vitamin E are in primarily higher-fat foods, such as vegetable oils, wheat germ, seeds and nuts.

ESSENTIAL FATTY ACIDS (EFA's)
Omega 3 (ALA, Alpha Linolenic Acid)
Omega 6 (LA, Linoleic Acid)

Background. Known as essential fatty acids (EFAs) because they are required for human health but cannot be synthesized by humans, **Omega 3** EFA (Alpha Linolenic Acid or ALA) **and its critical partner Omega 6** EFA (Linoleic Acid or LA) are oil-based building blocks of the cell's wall and act as oxygen magnets or sponges, grabbing oxygen from the blood stream and transferring it through the cellular walls into the cells themselves. Humans need EFAs to manufacture and repair cell membranes, enabling the cells to obtain optimum nutrition and expel harmful waste products. The combination of **Omega 3** and **Omega 6** are necessary for the proper functioning of the body's cardiovascular, reproductive, immune and nervous systems.

Relationship to glucose metabolism and diabetic control. Both **Omega 6 and Omega 3** fatty acids are essential in the management of diabetic patients. **Omega 3** has been used in the treatment of cardiovascular diseases, diabetes and lipid disorders. It is believed that Omega 3 has a hypolipidemic effect, reducing triglyceride levels significantly and LDL levels moderately, and inhibiting atherosclerosis. **Omega 6** is the most abundant polyunsaturated fatty acid in the human skin and play a vital role in preserving the epidermal water barrier.

Among the many metabolic alterations associated with diabetes, fatty acid metabolism is of major concern. As in eczema, the delta-6 desaturate enzyme is impaired in many diabetic patients, and without this enzyme the longer and more unsaturated fatty acids in the **Omega 6** pathway cannot be properly synthesized. This is thought to be one of the leading causes of diabetic neuropathy and retinopathy. Both animal and human studies have shown that the addition of Gamma Linoleic Acid (GLA) to the diet (a derivative of Omega 6) can stop and even reverse diabetic neuropathy by speeding up the nerve conduction velocity. The use of both **Omega 6 and Omega 3** has been recommended for diabetic retinopathy, as this may be a complication of both reduced **Omega 6** metabolites as well as a deficiency in **Omega 3.**

Effects of deficiency. **Omega 3 and Omega 6** deficiencies have been linked to increased appetite, increase in craving for sweets, diabetic neuropathy and retinopathy, cardio vascular diseases (heart attacks and strokes), Dyslipidemia (elevated cholesterol and triglycerides), arthritis, PMS, fatigue, lack of energy, eczema, dandruff, unhealthy hair and skin, decreased memory and mental abilities and attention deficit disorders (ADD, ADHD), and a host of other ailments.

The ideal ratio of **Omega 6 to Omega 3** should be between **1:1 and 3:1,** and should not exceed 4:1. A deficiency of either EFA – or an imbalance of EFAs ratio, can lead to serious health conditions, such as insulin resistance, diabetes, heart attack, obesity, cancer, depression, accelerated aging, stroke and Alzheimer's Disease, among many others.

Dietary sources. Both **Omega 3 and Omega 6** are poly-unsaturated fatty acids, naturally found in oil form. However, the processing or heating of these fatty acid oils during commercial production and cooking has eliminated a great deal of their natural health benefits. This is because the application of heat or the production of cholesterol-free food product substitutes (e.g., margarine, vegetable shortening) results in the partial or full hydrogenation (saturation) of these fatty acids and oxides and alters the EFA beyond the ability of our enzymes to recognize them.

Highest sources of Omega 3 EFAs are flax seed oil (which has the highest linolenic content of any food – 55%), pumpkin seed oil (15%) and fish oil. **Highest sources of Omega 6** EFAs are evening primrose oil (74%), safflower oil (15%), sunflower oil (40%, sesame oil (41%). Soybean oil and cottonseed oil should be avoided in the diet.