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Magnesium: The Beautiful Mineral

While reading Phyllis Balch's *Prescription for Natural Healing*, I noticed that for almost all disease conditions discussed in her book, magnesium supplementation was recommended. It sparked further questions in my mind: What was the connection? Is magnesium deficiency a widely known problem? Is there a basic, underlying mechanism which is failing for lack of magnesium, or is magnesium involved in so many processes that it influences just about every disease there is? These unanswered questions quickly led to my selection of the magnesium mineral for this research project. In fact, this topic has been so fascinating that I am embarking on my own supplementation trial, and I plan to submit my personal test results and supplementation regimen as an addendum to this paper.

Magnesium is vital to humans and other living organisms. Magnesium will be explored for its role in life processes and how it is supplied, and why it should be. Also, causative factors for magnesium deficiency will be examined, as well as its manifestations in various common disease states. Testing options and dietary and supplementation recommendations will be given to ameliorate the threat to vitality which low magnesium levels pose to the human body.

WHAT IS MAGNESIUM?

Magnesium is a mineral, which is defined as 'an inorganic compound of natural occurrence.' In its simplest definition, an inorganic compound is one that does not consist of the element carbon, indicating that it is not derived from living matter. (Wikipedia.org) Magnesium, along with calcium and others, is also termed an 'alkaline earth metal,' due to the presence of two electrons

in its outer shell in its element form. Because of these two valence electrons, magnesium reacts easily with other elements, and is found in nature only in compound form (dictionary.com). Essential in all living things, magnesium is the ninth-most abundant element in the universe (ancientminerals.com), the eighth-most abundant element on the face of our planet, and the third-most plentiful ion in seawater, after sodium and chloride (Czapp). Magnesium is also the fourth-most abundant mineral in the human body, (ancientminerals.com) and it is the second-most prevalent mineral at the intracellular level (Dean 12). When present to such a great degree, there can be no question that magnesium is responsible for many vital, life-sustaining processes. Its importance in preventative and curative therapeutics has long been recognized by traditional Chinese healers: the Chinese ideogram for magnesium consists of the symbols for "mineral" and "beautiful," and magnesium is known to them as "mei," the beautiful mineral (Sircus xiii).

THE ROLE OF MAGNESIUM

As one of the six macrominerals of the body, magnesium is required in over 700 enzymatic reactions, and body processes too numerous to examine in great detail within this paper. Its role, however, is multifaceted: magnesium is responsible for energy production, transport, enzyme activity, DNA and other cellular structure, nerve conduction, and much more. Working in concert with one another, magnesium and calcium are antagonists of one another, to create balanced electrolyte systems. Magnesium also helps to hold calcium in solution, rather than allowing it to form a precipitate, which tends to calcify structures. Without proper cellular structure, there is no body and without cellular energy and function, there is no life. Is it any wonder, then, that magnesium is also known as 'the spark of life?'

The Role of Magnesium: ATP and Energy, Transport, and Signal Transduction. Magnesium is a cofactor for the enzyme adenosine triphosphate (ATP). ATP is created in the mitochondria

within our cells, and is the main source of energy for the body. ATP must be bound to a magnesium ion to form MgATP, in order to be biologically alive. This is perhaps the most important function of magnesium, because ATP is made in each of the 100 trillion cells of the body. ATP is formed from the food we eat (carbohydrates, fats and proteins), in a series of chemical reactions, collectively referred to as the Krebs Cycle. Seven out of ten of the Krebs Cycle enzymes are dependent upon the presence of magnesium (Dean xiv).

Aside from providing energy, ATP functions in signal transduction and transport as well. A cell is highly responsive to specific chemicals in its environment. For example, hormones are chemical signals that tell a cell to respond to a change in conditions. Molecules in food or aromas communicate taste and smell through their interaction with specialized sensory cells. Signal-transduction pathways, or cascades, mediate the sensing and processing of stimuli. These molecular circuits detect, amplify, and integrate diverse external signals to generate responses such as changes in enzyme activity, gene expression, or ion-channel activity (Berg et al.). ATP, formed with the aid of magnesium, is used in various signal transduction pathways, which are further defined as sets of chemical reactions in a cell that occurs when a molecule, such as a hormone, attaches to a receptor on the cell membrane. The pathway is actually a cascade of biochemical reactions inside the cell that eventually reach the target molecule or reaction (dictionary.com). Transmembrane ATP imports substances necessary for cellular metabolism and exports wastes and toxins across cell membranes for removal. A hydrogen-potassium ATP pump, or gastric proton pump, acidifies the contents of the stomach for proper digestion. In addition, there are many other pumps and transporters in the body, all of which are directed by ATP with magnesium as the necessary cofactor (Dean xiv). For example, magnesium is a cofactor for the enzyme adenylate cyclase. This enzyme converts ATP to cAMP and

pyrophosphate; cAMP is used for intracellular signal transduction of the effects of hormones such as glucagon and adrenaline into cell, because the hormones are unable to pass through cell membranes. cAMP is also involved in the activation of protein kinases which in turn perform the function of adding a phosphate group to other proteins. In this way, protein kinases orchestrate the activity of almost all cellular functions. For example, protein kinases are used to regulate the effects of adrenaline and glucagon (Dean xv).

Apart from ATP, magnesium is a cofactor for the enzyme phospholipase C (PLC). PLC is a class of enzymes which split phospholipids at the phosphate group, thereby creating signal transduction pathways, among other things. In addition, magnesium is an important intracellular signaling molecule in its own right (Dean xiv). In summary, it becomes clear that magnesium is necessary for the actions of ATP as a power source for the body, as well as directs and coordinates cellular intake of nutrients and waste removal, and even helps to build the very transduction pathways themselves, as well as assisting and performing in the signaling processes, which are used to orchestrate cellular reactions. A beautiful mineral, indeed!

The Synthesis of Proteins, DNA and RNA. Magnesium is a requirement for the structural integrity of numerous body proteins. To date, 3,751 magnesium receptor sites have been identified on human proteins. Magnesium is also required for structural integrity of nucleic acids and is therefore needed for RNA and DNA synthesis (Dean xiv). It is responsible for control and differentiation of cell division, as well. Considering that our bodies replace old or damaged red blood cells alone at the rate of roughly 200 billion per day (Sakharoff), this illustrates the great need the body has for available magnesium.

Nerve Conduction and Muscle Function. Magnesium is intimately involved in nerve conduction. It stabilizes muscle and nerve cell membranes, which decreases the excitation of nerves and

contraction of muscle cells. The mechanisms of this are varied, and include oxygen uptake, electrolyte balance, and energy production. Magnesium allows muscles and nerves to function properly: present within the cell at a ratio of 10,000 times more magnesium than calcium, it allows some calcium into the cell to cause nerve conduction or muscle contraction, then pushes calcium out of the cells to allow for a relaxation phase. Without this modulation by magnesium, nerve cells would be overstimulated by calcium to a point of death, and muscles would go into uncontrollable spasm resulting in tissue damage, as in heart attack (Dean xvi).

Calcium and Other Ion Channels. Magnesium is directly involved in calcium channels: it jealously guards ion channels which allow calcium to enter and leave the cell, and orchestrates with precision the exact amount of calcium that is needed for the required excitatory process within the cell, then flushes calcium out to prevent excessive excitation within the cell. Magnesium is considered a natural calcium channel blocker, as opposed to the pharmaceutical type prescribed by medical doctors, which have many side effects. In addition to directly regulating calcium channels, magnesium is a cofactor for the enzyme guanylate cyclase, which then synthesizes cyclic guanosine monophosphate (cGMP). This enzyme keeps calcium channels open, allowing calcium to enter the cell as a second messenger. In smooth muscle, cGMP is the signal for relaxation, which can regulate vascular and airway tone, insulin secretion, and peristalsis. Magnesium also regulates other ion channels, most notably that of sodium and potassium. Magnesium aids the process of potassium transport across the cell membrane. (Dean xv)

Antagonist, Keeps Calcium In Solution. A key function of magnesium is as a calcium antagonist at the biochemical level. Calcium and magnesium share equal importance in our bodies, and neither can act without there being a reaction from the other. The activity of many enzymes

depend on a sufficient amount of intracellular magnesium—approximately 10,000 times more than calcium—would be negatively affected by small increases in levels of intracellular calcium. Magnesium is also necessary to keep calcium in solution in the body, and prevents calcium from becoming inappropriately deposited in soft tissues, a process known as calcification. As long as there is sufficient quantity of hydrochloric acid in the stomach, adequate amounts of calcium can be absorbed from foods; however, once calcium leaves the high acid environment of the stomach and enters the alkaline small intestine, magnesium is now needed to keep calcium in a soluble state. Without sufficient magnesium, calcification of the cells and tissues can occur at the cellular level, causing various serious health problems (Czapp).

MAGNESIUM: WHO NEEDS IT?

William Faloon, in his 2005 article "How Many Americans Are Magnesium Deficient?" attempts to scratch the surface of this far-reaching issue. He writes that "The latest government study shows a staggering 68% of Americans do not consume the recommended daily intake of magnesium. Even more frightening are data from this study showing that 19% of Americans do not consume even half of the government's recommended daily intake of magnesium" (Faloon). The National Academy of Sciences found that most Americans are possibly magnesium-deficient (qtd. in Dean 23). For reasons not fully understood, the body does not retain magnesium very well; certainly not as well as it holds onto calcium or iron, for example (Czapp). Even so, the hard numbers are not in yet. As will be seen in later sections, there is some difficulty when it comes to differentiating the symptoms, testing for and treating magnesium deficiency, as well as the willingness to spend research dollars to study its effects. A clearer concept of exactly who may be experiencing magnesium deficiency can be obtained by

examining risk factors, symptoms and disease processes, as outlined by Carolyn Dean, ND (see Appendix). Indeed, it appears that this list applies to most people, if not to all.

WHY ARE WE MAGNESIUM DEFICIENT?

The problem of magnesium deficiency is multifactorial. Starting with mineral-deficient soil and spanning all the way through to our modern lifestyle and the overuse of pharmaceuticals in allopathic medicine, various factors combine to create the perfect storm of low magnesium levels in the human body.

Bacteria- and Magnesium-Deficient Soil, Erosion and Acid Rain. The following statement, taken from the 1936 Senate document 264 as excerpted in *The Magnesium Miracle* by Dr. Dean reveals the state of our soil and food supply at that time:

> Do you know that most of us today are suffering from certain dangerous diet deficiencies which cannot be remedied until depleted soils from which our food comes are brought into proper mineral balance? The alarming fact is that foods (fruits, vegetables, and grains) now being raised on millions of acres of land that no long contain enough of certain minerals are starving us—no matter how much of them we eat. The truth is that our foods vary enormously in value, and some of them aren't worth eating as food. Our physical well-being is more directly dependent upon the minerals we take into our systems than upon calories or vitamins or upon the precise proportions of starch, protein, or carbohydrates we consume. Laboratory tests prove that the fruits, vegetables, the grains, the eggs, and even the milk and the meats of today are not what they were a few generations ago. No man today can eat enough fruits and vegetables to supply his stomach with the mineral salts he requires for perfect health, because his stomach

> isn't big enough to hold them! And we are turning into a nation of big stomachs (Dean xvii-xviii).

Kirkpatrick Sale, independent scholar and environmentalist, wrote about American agricultural practices in the June 5, 1995 edition of *The Nation* magazine, describing the assault on farmland by the post-World War II American farmer as having a similar approach to the warfare with machines and chemicals that was waged on the battlefield. This war on the land occurred because farmers were lured into the belief that killing pests and weeds was far superior to living in harmony with nature. The whole experiment backfired when it became apparent that using poisons on the soil indiscriminately killed essential nitrogen-fixing bacteria and worms, and the soil became dead and non-porous. Worms are needed to break up the earth and provide their own form of compost, and bacteria are necessary for plants to absorb nutrients; without their assistance, plants become weak and of inferior nutritional value (qtd. in Dean 25). In 1963, French biochemist and farmer André Voisin wrote a book titled *Grass Tetany*. In it, he described a metabolic disease of goats and cattle caused by eating grass which was grown in magnesium-deficient soil. These animals developed irritability, spasms and tremors, and subsequently would stagger and drop to the ground in convulsions at sudden, loud noises or if frightened or excited. Grass tetany due to magnesium deficiency as the proven cause had already been identified in the 1930s. It was observed that the low levels of magnesium found in these suffering animals could be corrected with injections of magnesium, which reversed these conditions. Voisin observed that intensive grazing practices and the overuse of mineral-deficient commercial fertilizers, which were common practices, were the culprits. Voisin identified that Holland was greatest user of commercial fertilizer on its pastures, and that Holland had the greatest incidence of grass tetany. Also, in the 1930s, potash (potassium) was the fertilizer of choice, due to its low cost and

easy uptake by plants; however, in an abundance of potassium, plants favor its absorption over magnesium and calcium, which are harder to absorb; this produces a crop which is magnesium-deficient (qtd. in Dean 25).

Erosion and run-off also are factors in mineral depletion of soil. In 1931, it was estimated that soil erosion was occurring at a rate of roughly one inch per year on cultivated land. (Bennett) A study published in 2006 found that the US is losing topsoil at a rate ten times that of the natural replenishment rate. (Powers) In acidic, light or sandy soils, magnesium itself is easily leached away. (Wikipedia.org) Based on measurements of dissolved magnesium in the Mississippi River, the annual estimated loss of magnesium from Midwestern soils is 7.1 million kilograms at least, and could be more if the magnesium in undissolved dirt carried in its currents were also included (Dean 26).

In addition to the loss of topsoil, magnesium depletion of the soil from acid rain occurs in three ways. First, magnesium leaching from the soil occurs in direct response to acid rain (Czapp). Next, the abnormal soil acidity caused by acid rain (which contains nitric acid), actually changes soil chemistry, causing a reaction with calcium and magnesium to neutralize the excess nitric acid. Eventually, calcium and magnesium become depleted, leaving the nitric acid to react with aluminum oxide in the soil, which is then taken up into the plant and decreases its survival ability. Finally, once the soil is tested and found to be particularly acid, it is usually treated with calcium oxide, also known as lime. This is another practice which would cause further magnesium deficiency in plants (Dean 26).

One would consider that since this problem has been going on for a long time, magnesium replacement for our arable land would be a common practice today. However, during research for this paper, a scientific article was found which touted magnesium soil

replacement (Mikkelsen); an agricultural extension service article referred to magnesium replacement, but stated it was not needed in all soils:

> The application of dolomitic limestone is the most cost-effective method for applying the magnesium that is needed. The magnesium content of dolomitic limestone varies from 8 to10%. To be effective, this magnesium source should be broadcast and incorporated before planting. There are fertilizers that are a combination of potassium sulfate and magnesium sulfate. The magnesium content is 11%. The sulfur concentration is 22% and the potassium oxide percentage is 22%. This fertilizer is easily used in a starter fertilizer for corn or as a magnesium source when there is no desire to increase soil pH. Although the need for the addition of magnesium to a fertilizer program is not widespread in Minnesota, this nutrient can increase crop production when needed. The potential for need should not be ignored. If there is doubt about the need, analyze the soil to be sure (Rehm et al.).

When examining the magnesium versus potassium percentage content of the above recommended fertilizers, it is important to note that potassium is present in double the amount of magnesium; as has been previously noted, plants will favor the absorption of potassium over magnesium in soil that contains an abundance of potassium. Since magnesium is the central ion in the chlorophyll molecule (Fiedor et al.), this does not potentially bode well for the crop. And this is true, as far as non-hybridized plants go. However, Katherine Czapp states in her article "The Neglected Mineral We Cannot Live Without":

> To add insult to injury, new plant hybrids are continually introduced that have been bred to survive on these mineral-depleted soils. Of course, when mineral-

> depleted crops are eaten by animals or by us, they will sooner or later cause disease. Even though organically raised crops should be a better bet nutritionally, this isn't always the case, and it pays in terms of your health to learn how your farmer replenishes the minerals on his fields (Czapp).

Together, these factors cause magnesium deficiency in our whole foods supply. But, what if the mainstay of the diet is not one consisting of whole foods?

Dietary Deficiencies, Junk Food and Processed Food. Coincidentally, with industrialized farming practices and soil depletion, the daily magnesium dietary intake in the US has fallen from 500 mg/day at the turn of the twentieth century, to 175-225 mg/day in 1994. The National Academy of Sciences has determined that most American men obtain about 80% of the Recommended Daily Allowance (RDA) for magnesium, and women average about 70% of the RDA (qtd. in Dean xviii). A 1988 US government study concluded that the standard American diet failed to provide the daily requirement of magnesium (Dean 23). Is it any wonder, given our limited soil supply of magnesium, that this situation prevails? Magnesium experts say the current RDA is inadequate to prevent magnesium deficiency (Dean xviii).

According to Ross Pelton RPh, PhD, CCN, the author of *Drug Induced Nutrition Depletion*, RDAs represent "the minimum wage of nutrition" (qtd. by Onusic). That the daily allowance of magnesium intake should be increased will become clear when taking into account diet and lifestyle factors in the sections which follow.

We a nation filled with junk food junkies: on average, roughly 90% of our food dollar is spent on junk food. Junk food makes up about 27% of the American diet. Magnesium experts have determined that the typical American diet, rich in fat, sugar, salt, synthetic Vitamin D, phosphates, protein, and supplemented calcium is not only deficient in magnesium, but actually

increases the need for magnesium in the body (Dean 23). Processed and synthetic foods and drinks with high sugar or alcohol content work to waste magnesium, as it is used to metabolize these foods and to detoxify the body as a result of their intake. The body requires at least 28 molecules of magnesium to metabolize a single molecule of glucose; fructose requires 56 molecules of magnesium—an unsustainable amount of magnesium loss (Dean xix), Aspartame and monosodium glutamate (MSG) are often contained in junk foods; they destroy nerve cells (neurotoxic, excitotoxic) and, being toxins, they themselves must be neutralized by magnesium (Dean 61). Phosphates in carbonated drinks and processed meats bind with magnesium to form insoluble magnesium phosphate, which is unusable by the body (Czapp). Processed foods are not much better. Magnesium content is significantly reduced in the refining and processing of processed and fast foods. Nearly all of the magnesium contained in grains is lost during the milling process, when bran and germ are removed from the whole grain to make white flour. White flour is used nearly exclusively to make hundreds of devitalized processed food items. A good example: one slice of white bread contains 6 mg of magnesium, whereas one slice of whole wheat contains 24 mg magnesium. When nuts and seeds are roasted, or their oils are extracted, magnesium is lost (Czapp). Magnesium is also lost into the water as it leaches out of vegetables as they are boiled. It would be a good idea to use this water as a broth when making soup, to reclaim its magnesium content (Dean 28). Foods tend to lose less calcium than magnesium through these processes; this adds to a problematic dietary calcium overload burden, and greater potential for calcification of cells and tissues (Czapp).

Diets: The Fad, The Good and The Blockers. Fad diets are still popular with people hoping to jump-start their weight loss process. Most notable among these, and one of the top five fad diets of 2015, is the Paleo diet. This diet is based upon the notion that as humans, it is beneficial from

a weight loss standpoint to eat the foods which would have been available to the hunter-gatherer caveman (Dean xviii). Vegetables, fruits and meat protein are stressed, while grains, legumes and refined sugar are eliminated. The problem with this fad diet is in the avoidance of grains and the emphasis on protein. Homocysteine, an amino acid and a normal by-product of protein digestion, must be processed by the body. The major enzymes involved in homocysteine metabolism are magnesium-dependent. When homocysteine is present at an elevated level, it causes the oxidation of cholesterol; this oxidated cholesterol damages blood vessels, as in the case of patients with heart disease. Oxidative degradation of fats occurs when there is a lack of magnesium (Dean 92). If it is necessary to be on a high-protein diet, an additional 300 mg magnesium should be supplemented daily (Dean 34).

Raw-foodies and green-juicers are not immune, either. Dr. Dean reports having consulted with people drinking more than 100 ounces of organic green juice per day, who still have symptoms such as heart palpitations and leg cramps. Even in the case of high-quality produce, magnesium and other nutrients can be depleted or lost after harvesting, through handling, refrigeration, storage and transport, even if done properly. Further storage of produce in one's own refrigerator continues this loss of nutrients, no matter their original source. And of course, unless the soil itself is replenished with minerals, even organic food will be mineral-deficient before it leaves the farm (Dean xix).

In addition, there are certain foods which contain chemicals which block the action of magnesium. For instance, tannins in some teas bind and remove all minerals from the body. Both oxalic acid (found in chard and spinach, cabbage, broccoli and brussels sprouts) and phytic acid (from hulls of seed and grain brans) block magnesium and other minerals by forming an insoluble compound with them. This causes minerals to be eliminated, rather than absorbed.

Oxalic acid is removed by cooking, so these vegetables should be steamed instead of eaten raw or juiced. Phytic acid can be removed by soaking grains and seeds for eight to twelve hours. In the case of soybeans, cooking does not destroy or eliminate phytic acid; only fermentation will reduce phytic acid, as in the case of miso and tempeh. Therefore, soy powder, soy milk, and tofu should be eaten in limited quantity only (Dean 34). Given this information, it is apparent that it is extremely difficult to obtain even the current RDA intake of magnesium by way of diet alone; this indicates that in addition to eating a high-quality diet, supplementation of magnesium is an absolute must.

Fluoridation. "Fluoridation of tap water is a disaster that threatens to afflict the population with an epidemic of arthritis and, by recent reports, cancer as well" (Dean 29). The proportion of imminent disaster is well understood, when one considers that as of 2003, roughly 60% of US cities were engaging in this form of mass medication of the populace, despite research findings by the *Journal of Dental Research* that the practice of water fluoridation is unrelated to a decrease in tooth decay rates. Chronic fluoride use has been linked to multiple health problems such as osteoporosis, arthritis, osteomalacia, and Alzheimer's disease. Five studies since 1990 show that the incidence of fractured hip in both older men and women are as much as 87% higher in areas with fluoridated water versus those in non-fluoridated areas. Fluoride is also found in toothpaste and in selective serotonin reuptake inhibitor (SSRI) antidepressant drugs, such as Prozac, Lexapro and Zoloft—the second-most prescribed class of drugs. The problem with fluoride is that it seeks out minerals such as magnesium and binds with them, creating a compound which has no bioavailability to the body. For example, magnesium fluoride, also known as sellaite, is an almost insoluble mineral compound which takes the place of magnesium in hard tissues, such as bone and cartilage; its brittleness makes bone susceptible to fracture.

(Dean 29) In addition, the fluoride salts most commonly used to fluoridate water supplies are hydrofluosilicic acid and sodium silicofluorides, which are waste products created by the phosphate fertilizer industry. In addition to binding any available magnesium in the body, the presence of fluoride increases the toxic load on the human body (Balch 137). As will be presented, since magnesium also plays a role in detoxification, increased magnesium intake is required to counteract the effects of these toxins as well.

Dehydration and Magnesium: A Symbiotic Relationship. The human body is composed of roughly 60 to 70% water; therefore, the importance of maintaining a state of adequate hydration with quality water cannot be stressed enough. However, in addition to water, magnesium has a role in the maintenance of the regulation of the body's temperature (Jensen 228, livestrong.com). Heavy sweating from endurance sports such as marathon running or strenuous exercise workouts can dangerously deplete magnesium stores and other electrolytes (except calcium), resulting in trembling, faintness and even seizures and death. The drenching sweats that some menopausal women suffer cause magnesium loss as well, and their diminishing magnesium levels worsen their jagged nerves, sleep disturbances, panic attacks, body aches and depression. (livestrong.com) Therefore, magnesium replacement for dehydration is a must. Since water follows minerals into the cell (DrCaronlynDean.com), and it is clear that water loss precipitates magnesium loss, which is then responsible for cooling the body, there is a clear indication that both hydration status and magnesium levels must be maintained adequately for good health, as each has a symbiotic effect on the other.

The Recent Emphasis on Calcium. In the 1970s, it was noted that there could be a connection between hip fractures in post-menopausal women and their calcium intake. Since that time, it has been a common practice for doctors to promote that their older female patients include calcium

supplementation as part of their medication regimen (Murray). The emphasis on calcium has diverted our attention from any other mineral. It seems that the tendency is to always look for the 'most important' or the 'star' and abandon teamwork. Due to its abundance in the body, calcium became the star. And, there has been magnesium research accumulated but not adequately publicized or discussed (Dean 22). However, more recent available information indicates that the allopathic medical community may be getting wise to the overwhelming evidence that excess calcium, or calcium toxicity, is creating problems in the human body—most notably, in the area of cardiovascular health (Pray). The average American diet is too high in calcium, and there seems to be a general lack of awareness of the necessity for balance between calcium and magnesium:

> Both calcium and magnesium are necessary for the healthy body—in proper balance to one another, as well as to other necessary minerals. Considered biochemical antagonists, one cannot act without eliciting the opposite reaction of the other. Yet calcium and magnesium must both be present in balanced amounts for either one to function normally in the body. Some researchers suggest that the healthy ratio of calcium to magnesium in the diet should be 2:1. Others consider 1:1 to reflect ratios that we evolved with based on our diet prior to the advent of agriculture. In modern industrialized countries the ratio from diet is from 5:1 to as much as 15:1. The imbalance of these two very important minerals produces many dire consequences in the body that are often overlooked by medical practitioners when treating the disease states they cause (Dean 21).

The connection is a simple one, when considering the antagonist effect that calcium has on magnesium levels, and that a magnesium-deficient state makes it impossible for calcium to

remain in solution, thereby causing the calcification of tissues. During the research of this paper, few sources were found in the arena of allopathic medicine, indicating that magnesium deficiency could be a cofactor in the calcification process, and an article written in 2013, entitled 'Magnesium and Osteoporosis: Current State of Knowledge and Future Research Directions' reported that:

> Although the evidence is still fragmentary, most of the experimental and clinical data available in the literature point to magnesium as a contributor factor to bone health. Consequently, optimizing magnesium intake might represent an effective and low-cost preventive measure against osteoporosis in individuals with documented magnesium deficiency, while doubts remain about supplementing the general population with the mineral since too much magnesium seems to have detrimental effects on the bone. (Castiglioni et al.)

Due to the presence of many other documented findings regarding the essential role of magnesium in the human body, it is apparent that the modern medical community should continue to pursue conscientious research pertaining to the benefits of magnesium. However, given the widespread use of highly-engineered pharmaceuticals in this country, it is possible that this type of research is not a top-priority goal.

Pharmaceutical Feeding Frenzy. The overwhelming use of prescription pharmaceuticals in the US is a well-known fact. When a doctor or patient fails to recognize an illness as one of many which have a direct and confirmed connection to magnesium deficiency and are treatable with magnesium (Czapp), the patient often ends up being treated with prescription drugs. Painkillers, diuretics, antibiotics, cortisone and other drugs further deplete magnesium and other minerals. The Mayo Clinic announced the results of a study in 2013, reporting that roughly 70% of

Americans take prescription drugs. In actuality, 79% were taking one prescription drug, 50% were taking two, and 20% were taking more than five prescription drugs. It went on further to report that ¼ of women age 50-64 are on an antidepressant drug. The Mayo Clinic reported that antibiotics are the most prescribed drug, and antidepressants are the second-most prescribed drugs (Sparks). Opiates are the third most prescribed drugs, and statins come in at fourth place. Expenditures on prescription drugs reached $250 billion in 2009, and accounted for 12 percent of total personal health care expenditures. According to the Centers for Disease Control and Prevention, the percentage of people using at least one prescription drug in the past month increased nearly fifty percent between 2007 and 2010. The researchers further predict that there is no end in sight, and that prescription drug spending will only increase in the future (Dean xxvii).

Perhaps, there is a reason for this. Pharmaceuticals is an industry which generates a higher profit margin than any other industry and is accustomed to multi-billion dollar malpractice fines. The pharmaceuticals industry has created every life-saving drug on the market, and has profited greatly for their efforts, which have not always been honest ones. In 2013, Pfizer made a profit margin of 47%, and a total of five companies made a profit of 20% or more. With the cost of a full course of some drugs at $100,000 or more, and production cost at only a small fraction of this, pharmaceutical companies are under some scrutiny for potential profiteering. They counter with pointing out that only about three out of every ten drugs developed actually ends up going on the market, and the research and development costs for all of these drugs must be recouped. However, the well-known accounting formula of TOTAL INCOME – TOTAL EXPENSE = PROFIT MARGIN already takes research and development costs into account, because they are included in the total expense of operating a company. Also,

drug companies fight to hold on to exclusive patent rights, often hiring “floors-full of lawyers” to parlay for even an additional one-month patent extension, which could mean big money to the drug company (Anderson). Kick-backs, expensive gifts, and the like have been the historic practice in the relationship of the pharmaceutical sales representative and the doctor; as scrutiny increases, limits have been placed on these practices. As of 2014, the Council of Europe was reported to be launching an investigation into "protecting patients and public health against the undue influence of the pharmaceutical industry” (Anderson). Unscrupulous practices are common in this industry, indicating how keen drug companies are to keep their hold on their market share. Table 1 on page 20 takes a look at the ten largest pharmaceutical corporations in the world in 2014.

Incredibly, the sky is the limit for Big Pharma, a term which has even entered the pages of the Cambridge dictionary. However, it does not make sense for us to continue along this track, given the way that the population is already paying these high premiums with their lives. Adverse drug reactions account for more than 100,000 deaths and 1.5 million hospitalizations per year. An additional 750,000 persons develop drug reactions after they are hospitalized. Thirty percent of all emergency room visits are drug-related (Czapp). Although pharmaceuticals may do a great deal of good in acute instances, to widely and exclusively promote their use in all situations over more natural means is an irresponsible approach, and a wholesale sellout of the general populace in the name of profit.

Table 1 (information compiled from www.therawatmagazine.com)

TOP 10 PHARMACEUTICAL COMPANIES IN THE WORLD – 2014 **(in ascending order by revenue)**						
Rank	**Corporation name**	**2014 Revenue (in billions)**	**Country of Origin**	**Year Founded**	**# of Employees**	**Famous for/notes:**
10	Gilead Sciences	24.5	USA	1987	7500	Antivirals for HIV, Hep C (12-week course costs $84,000)
9	AstraZeneca	26.09	UK/Sweden	1999	50,000	Cancer, neuroscience and inflammatory disease drugs
8	GlaxoSmithKline	34.65	UK	2000	97,921	Settlement paid for multiple criminal charges*
7	Sanofi S.A.	36.73	France	2004	112,128	Allegra (allergies), Frontline for pets
6	Merck & Co.	42.2	USA	1891	68,000	Vaccines: mumps, rubella, varicella, Hepatitis B
5	Bayer	45.84	Germany	1863	118,900	Aspirin, owns Monsanto
4	Roche Holding AG	47.63	Switzerland	1896	88,509	Benzodiazepines, Valium, Rohypnol;1999 paid $500mil in criminal fines
3	Pfizer	49.61	USA	1849	78,300	Zoloft, Lipitor, Viagra
2	Novartis	57.99	Switzerland	1996	120,000	Alcon (eye care); cancer drug Gleevec generated $4.7bil in 2015 alone
1	Johnson & Johnson	74.3	USA	1886	126,500	Baby products, Tylenol, Rogaine, many others

*In 2012, the company pleaded guilty to criminal charges in the United States. It agreed to pay a $3 billion settlement when it was convicted on a number of charges including promotion of drugs for unapproved uses, failure to report safety data about the diabetes drug Avandia, reporting false prices to Medicaid, and kickbacks to physicians. It was the largest health-care fraud case in American history and the largest settlement by a drug company.

To get a better window into exactly how pharmaceuticals work and react in the human body, it would be beneficial to examine the experience of one of the foremost magnesium experts, Mildred Selig, MD, who began her research career in the 1960s working for drug companies. There, she first noticed that many of the drugs' side effects were actually magnesium deficiency symptoms. It seemed apparent to Dr. Selig that many drugs seemed to cause a greater demand for and utilization of magnesium: for example, by acidifying the body, which then uses magnesium in order to neutralize the acid and to detoxify itself. Other drugs seemed to deplete magnesium from the body altogether, or else they pulled magnesium from storage sites and increased magnesium serum levels. The most common drugs in use today can create magnesium deficiencies (Dean 36):

- diuretics (for high blood pressure)
- bronchodilators, such as theophylline (for asthma)
- birth control pills
- insulin
- antidepressants
- Digitalis (digoxin; for fast heartbeat)
- tetracycline and certain other antibiotics
- corticosteroids (for asthma, COPD)
- cocaine
- nicotine

The interaction between pharmaceutical drugs and magnesium levels of the body does not end here. Muscle relaxant medications, barbiturates, hypnotics and narcotics may be enhanced by an adequate magnesium level, or by magnesium supplementation—less drug may be needed to achieve the same result. Many antibiotics cause magnesium loss—it may be necessary to stagger the doses of any magnesium supplement versus the antibiotic schedule. Diuretics act to lower the blood pressure by causing increased kidney filtration. This action throws off potassium and magnesium in the urine. Cardiac drugs, such as cardiac glycosides and digoxin,

also decrease magnesium levels, and require supplementation. Magnesium inhibits iron absorption, as well as the antibiotics tetracycline, ciprofloxacin, and vancomycin—magnesium supplementation should be staggered around these doses (Dean 37).

Aside from altered elimination of magnesium and its effect on pharmaceutical drugs, a more serious interaction can occur: that of drug-nutrient reaction. This reaction may change the effect of a drug, which could lead to malnutrition, provoke a state of altered metabolism, or cause a nutrient imbalance. For instance, a classic and well-known interaction is the interaction between grapefruit juice and simvastatin—grapefruit juice increases bioavailability of this drug, which renders simvastatin toxic (Bollate qtd. in Onuses). There are more examples of drug-nutrient reactions. Antiepileptic drugs adversely affect vitamin D and K; they affect folate metabolism, biotin status, carnitine status and bone health, and they can cause liver toxicity. Antipsychotic drugs are associated with weight gain, hyperglycemia and elevated lipids (Bollate qtd. by Onusic). Drugs may also cause nutrient depletions by altering the appetite, interfering with taste or smell, inducing nausea, vomiting or diarrhea, causing dry or inflamed oral mucosa, changing the acidity of the digestive tract, damaging the cells, binding to nutrients, or competing for enzyme systems or transporters (Rolfes qtd. in Onusic). Most commonly, drugs affect the cytochrome P450 pathway, a metabolic pathway which is basically a system within the liver through which drugs and other toxins travel in order for the body to make them more water-soluble for elimination (Onusic, anaesthetist.com). Also, drugs themselves or their delivery systems (capsule, coatings, etc.) can cause problems in the body. For instance, the coating on enteric coated aspirin contains 50 mg of aluminum, which has been implicated in the development of senility and dementia (Onusic). Acid-reducing proton pump inhibitor medications (Prilosec, Protonix and others) have been known to cause brittle bones, and a

decrease in intrinsic factor in the small intestine; decreased intrinsic factor leads to decreases in vitamin B_{12} absorption, and low vitamin B_{12} levels results in poor DNA replication (Onusic), a condition that can perpetuate cancer.

This illustrates that pharmaceuticals, liberally and extensively given to cure, control or alleviate a problem, often end up causing further problems in the human body due to their side effects and the alterations to human metabolism which they create. In essence, all of the symptoms "treated" by these drugs eventually become worse (Czapp). Drug companies guard their market share with zeal, and sometimes, through blatant criminal behavior. This leads to the conclusion that due to the potential financial gain at stake, the pharmaceutical industry would like to maintain their exclusive status and will protect this status through various means, also including indoctrination of the public through advertising. Drug interactions with one another have not been investigated in this paper; they themselves are still being discovered by the medical community, and this discussion should suffice in achieving its goal of examining the role which pharmaceuticals play in maintaining our transient health and our long-term illness. Pharmaceuticals can at best be viewed as nothing more than a temporary patch. One cannot help but think that there must be a better, more integrous alternative. That better alternative is available, by the name: Magnesium. Before an examination can be made of the benefits of magnesium, a few more reasons for how its deficiency occurs and the manner in which deficiency contributes to disease must be investigated.

Stress. Stress is so common in our daily life that we have become desensitized to it and the message it is trying to give us, which is to slow down (Dean 49). A 2011 study by released in January of 2012 by the American Psychological Association, entitled "Stress in America: Our Health At Risk" states that more than half of Americans reported personal health problems (53

percent) as a source of stress, up from 2009 (47 percent), and that more than half (56 percent) of adults say they are doing an excellent or very good job of knowing when they are feeling stressed, but only about half as many (26 percent) report doing an excellent or very good job at preventing themselves from becoming stressed (apa.org) These figures show that at least half of us are ill due to stress, and only about one-quarter of us know how to deal effectively with it. This is of great concern with regard to magnesium. Anxiety in and of itself is not a bad thing—it is, in fact, a mechanism for adaptation to stress. It is a chemical reaction which is created when the adrenal glands respond to a stressful event, such as low blood sugar, by releasing adrenaline. Adrenaline is very useful when trying to escape from a dangerous situation, because it stimulates fight-or-flight response of the sympathetic nervous system: the heart pumps faster, digestion slows and energy stores are released from liver and made available to heart, lungs and muscles (Dean 49). However, mental and physical stress, with its related continuous flow of adrenaline, use up magnesium rapidly. Adrenaline increases heart rate, blood pressure, vascular constriction and muscle contraction. All of these actions demand a steady supply of magnesium for smooth function. The nervous system also depends upon sufficient magnesium levels, due to its action as a natural relaxer and calcium channel blocker. Magnesium is important to the healthy functioning of the parasympathetic nervous system, which induces a state of calm. We are actually designed to operate, for the most part, in a calm, relaxed parasympathetic state; we are not designed to be in a chronic state of heart-pounding, stress- and adrenaline-driven sympathetic dominant fight-or-flight readiness. This constant state of stress for many of us, leads to chronic stress, irritability, anxiety, fatigue, insomnia along with concomitant magnesium loss, and ultimately, adrenal exhaustion, hypertension, heart disease and other conditions which would be considered by some to be worthy of pharmaceutical intervention. Magnesium operates as a

natural calcium channel blocker to aid relaxation (Czapp). However, given the state of fast-paced society today, it is not surprising that magnesium deficiency due to continual levels of stress is a pervasive condition.

Digestive Problems, Absorption Difficulties, and Gut Dysbiosis. Inadequate production of stomach acid is one of the first problems in digestion. Stomach acid is required for chemically changing minerals into an absorbable form through ionization. Elderly persons, as well as those with arthritis, asthma, depression, diabetes, gallbladder disease, osteoporosis, or gum disease often tend to be deficient in hydrochloric acid. To make matters worse, if magnesium is deficient to begin with, gastric acid production is diminished, which hinders magnesium absorption even more: and all of these conditions are also associated with magnesium deficiency. Compounding the problem is that America has an addiction to antacids, because of our intake of sugary junk food and greasy fast foods which ferment in the stomach and cause a backflow of pancreatic enzymes from the small intestine (Dean 30). In addition, if calcium carbonate antacids are used, they act on cue as the magnesium antagonists they are, and cause more magnesium to be excreted. At this point, calcium will not be able to stay in solution due to inadequate supply of magnesium, it cannot be absorbed properly and is deposited into soft tissues. The result is constipation due to interference with bowel muscle contractions, kidney stones due to the precipitation of calcium, and bladder irritability due to bladder wall calcification, to name a few (Czapp).

Then, there is the problem of yeast overgrowth. *Candida albicans*, also known as yeast, is a fungus which typically lives unnoticed in the large intestine. When it moves into the small intestine, it projects threadlike structures which punch tiny holes into the lining of the gut—this condition is called leaky gut. This creates difficulty with the absorption of nutrients, and sets up

and environment where toxins are readily absorbed into the body (Dean 33). Excessive proliferation of yeast in the small intestine is a powerful trigger of inflammation throughout the body. Yeast produces 178 chemical antigens which are molecules capable of causing the immune system to produce an immune response in its normal life cycle. These antigens are absorbed into the bloodstream and start a never-ending inflammatory cascade to occur. Also, the body becomes more susceptible to the absorption of toxins by the gut. Acetaldehyde is a toxin which affects the brain, liver, and kidneys, and depletes B vitamins. It can also block hormone receptors affecting the thyroid, adrenals, and pituitary. For example, symptoms of thyroid imbalance are very common today, partly because thyroid hormones which appear at normal levels in the bloodstream cannot get inside cells to do their work as a result of chronic acetaldehyde poisoning. There are several additional ways humans can be exposed to acetaldehyde—through alcohol consumption, cigarette smoking, exhaust, and intake of high-fructose corn syrup. Acetaldehyde is a powerful toxic by-product of yeast, and magnesium is needed to break it down. Without enough magnesium, acetaldehyde creates many side effects. Ironically, yeast overgrowth from the large intestine into the small intestine occurs under the influence of antibiotics, cortisone and other steroids, birth control pills, estrogen, and a high-sugar diet. These disrupt the normal beneficial bacterial flora, or microbiome, of the gut, which serve to protect against this type of invader, a condition known as gut dysbiosis. Yeast toxins, inflammatory products the body creates to neutralize them, and undigested food molecules all form barriers to the absorption of dietary and supplemental nutrients, including magnesium (Dean xxviii). Similarly, Irritable Bowel Syndrome (IBS) causes severe difficulty with absorption of nutrients. In order for magnesium levels to be optimized, correct stomach acidity, yeast overgrowth, food

allergies, IBS and other absorption conditions must be addressed in order to achieve maximum absorption of this mineral (Czapp).

Overwhelmed by Environmental Poisons: Metals, Pesticides, and Pollutants. Magnesium is utilized by the body for all sorts of detoxification pathways and is necessary for the neutralization of toxins, overly acidic conditions that arise in the body, and for protection from heavy metals. It plays a vital role in protecting us from the onslaught of man-made chemicals all around us. Glutathione, an antioxidant normally produced by the body and a detoxifier of mercury, lead and arsenic among others, requires magnesium for its synthesis (Czapp). In addition, magnesium itself binds with and helps to eliminate heavy metals (Dean 180). In our toxic environment today, magnesium has plenty of detoxification work to perform. Dr. Dean neatly describes the enormous problem we are faced with:

> In an important environmental study, toxic chemicals were found in nearly all foods tested by the FDA at levels consistent with negative health effects. They included persistent organic pollutants such as DDT and dioxin, which have been banned in the United States for decades but are still produced in other countries. Exposure to minuscule levels of these chemicals at crucial times in fetal and infant development can disrupt or damage human hormone, reproductive, neurological, and immune systems. …In 1985, the US Environmental Protection Agency published a survey of human fat composition. It found that more than 99 percent of the population has measurable levels of the nine chemicals they tested for, including PCBs and DDT. In 2000, 100 percent of fat samples tested were positive for chemicals. …In 2000 the CDC released the very first large-scale national survey of environmental toxins from human samples, and the results are

> startling. Blood and urine levels of twenty-seven chemicals tested in 5,000 Americans far exceeded safe levels. The EPA and CDC mostly rely on air, water, and soil samples to test for toxic levels of chemicals. Even then, only a few dozen of the more than 100,000 chemicals in everyday use are monitored for safety. Hopefully this human study will reinforce a cutback in chemical pesticide use, as pledged by the US Department of Agriculture (USDA) and the US Environmental Protection Agency (EPA) in 1993. Chemical pesticide use, however, has increased from 900 million pounds in 1992 to 940 million pounds in 2000, while total cropland has decreased. And the riskiest chemical pesticides, such as organophosphates and carbamates, probable or possible carcinogens, still account for over 40 percent of the pesticides used in U.S. agriculture" (qtd. in Dean 183-184).

Since magnesium is used in the binding and elimination of heavy metal toxins especially, it is blazingly apparent that the human body, taxed like never before with poisonous substances in the environment, dental treatments, food supply and others, has assumed a state of perpetual magnesium deficiency due to this travesty alone.

Magnesium Wasting. There are conditions in which magnesium is easily wasted from the kidneys, but in general this is a rare genetic defect. Although costly and inconvenient, these are usually treated in conventional medicine with intravenous magnesium (Dean 38). However, there is another phenomenon where magnesium deficiency itself seems to cause a condition which promotes magnesium wasting:

> Magnesium-deficiency studies on the kidneys have shown intraluminal calcareous deposition in the corticomedullary area and damage to the tubule epithelium.

> Damage to the kidneys from magnesium deficiency creates a situation that intensifies magnesium deficits. Micropuncture studies have shown that most active renal tubular reabsorption of magnesium occurs at sites that are potentially damaged by magnesium deficiencies, meaning these conditions can cause renal tubular magnesium wasting. Both hyperparathyroidism and hypervitaminosis D increase blood and thus urinary loads of calcium and thus cause even further magnesium loss. Most renal reabsorption of magnesium occurs in the proximal tubule and the thick ascending limb of the loop of Henle. In hypomagnesemic patients, the kidney may excrete as little as 1 mEq/L of magnesium. Magnesium will be removed from bone stores in times of deficiency. Primary renal disorders cause hypomagnesemia by decreased tubular reabsorption of magnesium by the damaged kidneys. This condition occurs in the diuretic phase of acute tubular necrosis, post-obstructive diuresis, and renal tubular acidosis. (Sircus 19)

It is clear to see that adequate magnesium levels must be maintained in the body, to prevent this particular magnesium-wasting condition caused by damage to the kidney.

Now that several of the main contributors to magnesium deficiency have been identified, it is important to translate this information into a language which can help us truly understand the devastating effect that low magnesium levels have on the human body, and exactly how wide-ranging the problem truly is.

CONDITIONS CAUSED BY MAGNESIUM DEFICIENCY

Anxiety/Depression. According to 2005 statistics, roughly forty million Americans, or 18% of the population age 18 and over, suffer from some form of anxiety (aada.org). In addition, in 2015, an estimated 16.1 million adults aged 18 or older in the US had at least one major

depressive episode in the past year. This number represented 6.7% of all U.S. adults (nimh.nih.gov). According to Peter Wehrwein, contributor at Harvard Health Publications:

> The National Center for Health Statistics (NCHS), the rate of antidepressant use in this country among teens and adults (people ages 12 and older) increased by almost 400% between 1988–1994 and 2005–2008. The federal government's health statisticians figure that about one in every 10 Americans takes an antidepressant. And by their reckoning, antidepressants were the third most common prescription medication taken by Americans in 2005–2008, the latest period during which the National Health and Nutrition Examination Survey (NHANES) collected data on prescription drug use" (Harvard.edu).

Other statistics quoted by Wehrwein denote that 23% of women in the 40s to 50s age group take antidepressants, a higher percentage than any other group; women are 2 ½ times more likely to be taking an antidepressant than men. Antidepressant use does not appear to vary by income status (Harvard.edu). The statistics show an outstanding prevalence of anxiety and depression in our country. Even children are susceptible to depression and anxiety and are being medicated for these conditions. The fact that prescription antianxiety agents and antidepressants are being used at an unprecedented rate only contributes to magnesium deficiency, in that it has been observed that prescription drugs increase the demand for magnesium in the body. The pharmaceutical industry has focused its research of depression on SSRIs in order to capitalize on the effects of serotonin, the 'feel-good' chemical. SSRIs artificially flood the body with serotonin by preventing its breakdown and elimination, theoretically to cause mood elevation. What the body really needs, however, is magnesium. Patients have different reactions to SSRIs: some are relieved of depression, some become anxious and irritable, and still others feel relief enough

from apathy to be able to act on suicidal or homicidal thoughts. Still other patients experience flattened moods, where they can neither laugh nor cry; this keeps them from depression, but they are doomed to an emotionless life (Dean 56).

Depression is related to stress and anxiety, and also to magnesium deficiency. During the stress reaction, adrenaline levels increase, which wastes magnesium. In fact, magnesium depletion itself stresses the body, which results in panic attacks, which yields more stress (Dean 50). During experiments in which adrenaline was given intravenously, a decrease in magnesium, calcium, potassium and sodium occurred. When the IV adrenaline was stopped, the body recovers in thirty minutes; however, magnesium takes much longer to reach normal levels (Dean 47). Serotonin, the "feel good" hormone, requires magnesium in its delicate balance of release and reception by cells in the brain. Only when adequate magnesium levels are present in the body can mental and emotional equilibrium be experienced (Czapp). A study by Dr. R.H. Cox and Dr. C.N. Shealy revealed that out of 500 depressed study participants, the majority were found to be magnesium deficient (Cox et. al qtd. in Dean 46). Other clinical trials have proven out that magnesium deficiency can be an underlying cause of anxiety and depression (Dean 48).

Migraines. As defined by the National Institutes of Health (NIH), a migraine is a type of headache. It may occur with symptoms such as nausea, vomiting, or sensitivity to light and sound. In many people, a throbbing pain is felt only on one side of the head (medlineplus.gov). Twenty-five million Americans suffer from migraines, statistically women more than men especially in the 25 to 50 year age group (Dean 63). Some of the clearly identified triggers or factors that cause these headaches include: allergies and allergic reactions; bright lights, loud noises, and certain odors or perfumes; physical or emotional stress; changes in sleep patterns; smoking or exposure to smoke; skipping meals or fasting; and alcohol. (Sircus 275). In addition

to these, the NIH also includes the following known triggers for migraine: caffeine withdrawal; changes in hormone levels during a woman's menstrual cycle or with the use of birth control pills; exercise or other physical stress; stress and anxiety; chocolate; dairy foods, especially certain cheeses; foods containing monosodium glutamate (MSG); foods with tyramine, which include red wine, aged cheese, smoked fish, chicken livers, figs, and certain beans; fruits (avocado, banana, citrus); meats containing nitrates (bacon, hot dogs, other cured meats); onions; peanuts and other nuts and seeds; and processed, fermented, pickled, or marinated foods. (medlineplus.gov) Table 2 shows the possible relationship between these triggers and magnesium deficiency, as taken from this information.

Table 2: Migraine Triggers and Their Possible Relationship to Low Magnesium Status

MIGRAINE TRIGGER	RELATIONSHIP TO LOW MG++
Allergies and allergic reactions	Antigen production
Bright lights	Adrenaline, stress
Loud noises	Adrenaline, stress
Certain odors or perfumes	Environmental toxin/sensitivity
Physical or emotional stress	Adrenaline, stress
Changes in sleep patterns	Adrenaline, stress
Smoking or exposure to smoke	Environmental toxins
Skipping meals or fasting	Adrenaline, blood sugar, elimination of toxins during healing crisis
Chocolate	Antigen production
Alcohol	Elimination of magnesium, dehydration, toxin, alters blood sugar
Dairy foods, especially certain cheeses	Allergy/antigen production, possible environmental toxins, tyramine (toxin)
Foods with monosodium glutamate (MSG)	Excitotoxin
Foods with tyramine, which includes red wine, aged cheese, smoked fish, chicken livers, figs, and certain beans	Toxins, tyramine (toxin), excitotoxins
Fruits (avocado, banana, citrus fruit)	Antigen production
Meats containing nitrates (bacon, hot dogs, salami, cured meats)	Toxins, excitotoxins
Onions (rare)	Antigen production
Peanuts and other nuts and seeds	Antigen production, excitotoxins
Processed, fermented, picked, or marinated foods	Toxins, tyramine, excitotoxins

From this table and the information that has been presented, it is easily extrapolated that the underlying mechanisms behind each migraine trigger are those which have been identified as inherently requiring detoxification, neutralization, or some other mediation by magnesium, and that deficient magnesium levels would preclude these processes. Also, it should be noted at aspartame is missing from this list, and should be considered an excitotoxin, which can cause migraine in the absence of adequate magnesium (Dean 61-62).

Conditions common to females which trigger migraines are also associated with magnesium deficiency, including pregnancy and menstruation. In non-menopausal women,

estrogen rises before the period, causing a shift of blood magnesium into bones and muscles; as a result, magnesium levels in the brain are lowered (Dean 64, 133).

In addition to this symptom-based evidence which has long been known, research studies have been performed which have borne out the magnesium connection in the evolution of migraines:

- Dr. Alexander Mauskop, director of the New York Headache Center, working with Drs. Bella and Burton Altura, administered 200 mg of magnesium daily to a group of 3000 patients; there was an 80% reduction in their migraine symptoms. This study did not have a control group, so results could be questioned, but it aroused a great deal of excitement and triggered a flurry further research on migraines and magnesium (Dean 64).
- Subsequent studies of migraine patients confirmed a common pattern and support role for magnesium deficiency in the development of headaches. The researchers found that infusion of magnesium resulted in a rapid and sustained relief of acute migraine. Because of an excellent safety profile and low cost, they recommend oral magnesium supplementation for migraine sufferers at a level of 6mg/kg/day (Dean 65).
- Another research team treated 81 patients who suffered ongoing migraine headaches with 300 mg of magnesium twice a day. The frequency of migraines was reduced by 41.6 percent in the magnesium group but by only 15.8 percent in a control group that received placebos. The number of migraine days and drug consumption for pain also decreased significantly in

> the magnesium group. High-dose oral magnesium appears to be effective in migraine treatment and prevention (Dean 66).

Besides aiding in the detoxification of antigens and toxins, the mechanism for the help that magnesium provides for the migraine sufferer are manifold. Magnesium prevents platelet aggregation, acting as a blood thinner, which prevents tiny vessels from blockage and vessel spasm which impede blood flow. It modulates hyperactive brain neurotransmitters and regulates the inflammatory process, which both play a role in migraines when they are imbalanced. Finally, magnesium relaxes head and neck muscles, thus preventing lactic acid buildup which, along with tense muscles, can worsen head pain. It should be briefly mentioned that the condition of low blood sugar, or hypoglycemia, is an aggravating factor in migraine (Dean 61); it will be examined in the next section on Metabolic Syndrome X and Type 2 Diabetes. Without a doubt, magnesium should be the drug of choice when it comes to treating migraine headache, and the allergies which are implicated as triggers, as it can unquestionably be considered a deficiency syndrome.

Metabolic Syndrome X and Type 2 Diabetes. Metabolic Syndrome X, or Metabolic Syndrome, is a group of five risk factors for the development of heart disease, diabetes, and stroke. The five risk factors include: increase blood pressure (greater than 130/85), high blood sugar levels (insulin resistance), excess fat around the waist, high triglyceride levels, and low levels of good cholesterol, or HDL. If a person has one of these risk factors, it does not mean that they have developed metabolic syndrome. However, having one of these risk factors will increase the chances of developing cardiovascular diseases. Having three or more of these factors will result in a diagnosis of metabolic syndrome and will further increase the risk of health complications. The American Heart Association (AHA) reports that as of 2014, 35 percent of adults currently

have this condition in the US (Burke). Type 2 Diabetes is a condition characterized by high blood glucose levels caused by either a lack of insulin or the body's inability to use insulin efficiently. Type 2 diabetes develops most often in middle-aged and older adults but can appear in children, teens, and young people. It is estimated that 29 million people, or approximately 9.3 percent of the U.S. population, have Type 2 diabetes: 21 million who have been diagnosed with it, and 8.1 million who are as yet undiagnosed (cdc.gov). Metabolic Syndrome X plays an important role when examining both Type 2 diabetes and cardiovascular health and illness, because it is considered to be a precursor to both. The greater connection, however, will be better understood when examining the dance that occurs between magnesium and insulin.

Insulin is a natural endocrine hormone which is produced by the beta cells in the islets of Langerhans in the pancreas. Insulin allows cells to utilize glucose for energy; in fact, cells cannot utilize glucose without insulin. Insulin also causes glucose to be stored as glycogen in the liver and as fat, thereby regulating the level of glucose in the bloodstream. In Type 1 diabetes, the beta cells fail to make enough insulin. In contrast, in Type 2 diabetes, the beta cells are producing insulin, but cells throughout the body are not responding normally to the insulin. This is phenomenon is termed *insulin resistance* (medicinet.com). Aside from these very vital functions, it is not appreciated that insulin serves various other functions in regulating each of the following (Sircus 13):

- Lifespan—lower insulin levels equate to a longer life
- Blood sugar
- Blood lipids
- Excess nutrients (from glucose, carbohydrates and calories) are converted to fat
- Muscle building

- Protein storage
- Magnesium levels
- Calcium levels
- Retains sodium levels
- Cell division
- Liver functions
- Sex hormones, estrogen, progesterone, testosterone
- Cholesterol in the body

As amazing as this process is, there is another actor in the wings of the insulin stage: magnesium. However, as in its relationship with calcium, magnesium works closely with insulin in a myriad of ways. Magnesium and insulin need each other very much. Magnesium is necessary for both the action of insulin and its manufacture. Without magnesium, the pancreas won't secrete enough insulin—or the insulin it secretes won't be efficient enough—to control blood sugar. In fact, Type 2 diabetes is associated with magnesium depletion. A growing body of evidence suggests that magnesium plays an important role in reducing cardiovascular risk, and may be directly involved in the development of Type 2 diabetes itself. Low serum and intracellular magnesium concentrations are associated with insulin resistance, impaired glucose tolerance, and decreased insulin secretion. Without insulin, though, magnesium is not transported from blood into cells where it is most needed. Dr. Mark Sircus notes that Dr. Jerry Nadler and colleagues put 16 healthy people on magnesium-deficient diets and noted that their insulin became less effective at moving sugar from their blood into cells to be burned or stored as fuel. In other words, they became insulin resistant. Insulin resistance and magnesium depletion result in a vicious cycle of worsening insulin resistance and decrease in intracellular magnesium, which

limits the role of magnesium in vital cellular processes. If cells become resistant to insulin, or if insufficient amounts of insulin are produced, then little magnesium enters the cell where it is needed. When insulin processing becomes problematic, magnesium is excreted via the urine; this process is called magnesium wasting disease (Sircus 10-14).

Magnesium is also an important cofactor for enzymes involved in carbohydrate metabolism; its depletion threatens overall metabolism. Magnesium also helps correct abnormal lipoprotein patterns. Magnesium replacement improves insulin sensitivity, which in turn can markedly reduce triglyceride levels. Reduced triglyceride availability, in turn, reduces very-low-density-lipoproteins (VLDL) and low-density lipoproteins (LDL), both of which have been implicated in cardiovascular disease. Magnesium supplementation can also raise levels of beneficial high-density lipoproteins (HDL) (Sircus 13).

When magnesium levels fall, hypersecretion of adrenaline and insulin compensate. Their increased secretions help maintain the constancy of the levels of intracellular magnesium in the soft tissues. Plasma and intracellular magnesium concentrations are tightly regulated by insulin. According to Dr. Ron Rosedale, “Extra insulin floating around in the blood causes plaque build-up. They didn’t know why, but we know that insulin causes endothelial proliferation. Every step of the way, insulin is causing cardiovascular disease. It fills the body with plaque, it constricts the arteries, it stimulates the sympathetic nervous system, and it increases platelet adhesiveness and coagulability of blood” (Sircus 14). Ultimately, when magnesium levels drop there is a cascade of physiological problems that corrupt heart health. Magnesium deficiency is also associated with increased intracellular calcium, which could also lead to insulin resistance (Sircus 14). There is also a connection between high blood pressure and diabetes, due to the constriction of blood vessels that occurs in the absence of magnesium due to insulin resistance

(Sircus 11). Finally, several studies have shown that daily oral magnesium supplementation improved insulin sensitivity by 10 % and reduced blood sugar by 37 %. This confirms that magnesium plays a key role together with insulin in preventing diabetes and cardiovascular disease, the very ravages which Metabolism Syndrome X predicts.

Cardiovascular Illnesses: Cholesterol/Hypertension, Stroke and Coronary Artery Disease. It has been established the role which magnesium, together with insulin, plays in the alleviation of endothelialization of blood vessel walls, lipoprotein excess, plaque formation, platelet aggregation and vessel spasm. Using this concept as a basis, hypertension, stroke and coronary artery disease will be examined, with specific additions for how magnesium deficiency helps to precipitate each, and how these disease states may be helped by the 'beautiful mineral.'

The AHA still reports that cholesterol is one of the major controllable risk factors for cardiovascular disease (heart disease, heart attack and stroke). And, high cholesterol along with high blood pressure, is considered a recipe for disaster (heart.org). In fact, high blood pressure is an even stronger predictor of cardiovascular risk than high cholesterol (Sircus 108). During this research, one article was found which would indicate that there may be no direct relationship between high cholesterol and high blood pressure (ncbi.nih.gov). However, the medical community still regards cholesterol with a watchful eye. Cholesterol is a form of fat which circulates in the blood, and gets stored in the liver. It has many useful functions in the human body: it stabilizes cell membranes, insulates nerves while comprising 60-80 % of our brain tissue, it is used to make hormones, for proper food absorption and to make bile salts. Cholesterol comes in three basic types. HDL are generally considered beneficial because they remove cholesterol from blood vessel walls and move it to the liver for processing and excretion. LDL are considered to be harmful because they move cholesterol into the bloodstream, which is

thought to create plaque buildup in vessels. Finally, VLDL, which can be made into LDL, are considered potentially harmful as well (Dean 84). However, these three types of cholesterols are normally present in the blood. What is not normal is the high amounts of oxidized cholesterol—that is, cholesterol abnormally bound to oxygen—which is present in the body due to the intake of processed, fried, and fast foods. Chlorine, fluoride, pesticides, and other pollutants also oxidize cholesterol; it is this oxidized cholesterol that is of concerned when it comes to heart disease (Dean 85). At one time, the public was conditioned to believe that cholesterol was bad; this spawned the introduction of hydrogenated oils; research in the 1990s proved that these oils were more dangerous that saturated animal fats (Dean 86). In any case, the cholesterol scare is big business for doctors and drug companies: statins are the fourth-most prescribed type of drug today. The liver produces about 1000 mg of cholesterol per day. Statins are powerful drugs which block an enzyme in the liver to lower cholesterol. However, this enzyme does much more in the body, so this type of suppression causes severe consequences. Statins disrupt liver functions and require periodic blood testing for liver damage. If liver damage is present, discontinuing the statin drug usually reverses the problem. Also, a well-known side effect of statins, or statin myopathy, is caused by muscle cell destruction called rhabdomyolysis, which leads to pain and tenderness. And along with muscle destruction comes the loss of magnesium which was stored in these sites. Statins also bind irreversibly with magnesium, which also contributes to muscle pain (Dean 89). However, a safer alternative is magnesium therapy. Liver cholesterol production requires an enzyme called HMG-CoA reductase; magnesium slows this enzymatic reaction when present in sufficient quantities. Magnesium is a natural way to control cholesterol when it reaches a certain level. In contrast, statins destroy the whole process and deactivates Coenzyme Q-10 in its wake—which causes muscle and nerve damage, memory

decline, amnesia, and cardiomyopathy. Magnesium is also heart-protective in that it lowers LDL, raises HDL, and lowers triglycerides. As an added benefit, another magnesium-dependent enzyme converts Omega-3 and -6 fatty acids into prostaglandins, which promote heart health and overall health (Dean 90).

A stroke, or cerebral vascular accident, is defined as "the sudden death of brain cells due to lack of oxygen, caused by blockage of blood flow or rupture of an artery to the brain. Sudden loss of speech, weakness, or paralysis of one side of the body can be symptoms" (medicinenet.com). Stroke is said to be caused by hypertension, atherosclerosis, and diabetic complications, all of which are associated with low magnesium. Strokes have devastated the lives of 4.6 million Americans, and 15 million people worldwide; each year about 700,000 new strokes occur, along with 100,000 recurrences, and statisticians say that the incidence of stroke is increasing (Dean 78). In fact, at the end of 2009, a stroke crisis in Europe has already cost the regional economy an estimated $56 billion a year, with numbers expected to rise as the population ages (Sircus 101). The University Hospital of New Jersey estimates the rates of ischemic-type stroke (caused by long-term plaque buildup and blood clot) to be in the vast majority at 83% (uhnj.org). This is an area in which magnesium can be of benefit. Studies show that when normal or elevated magnesium is present in the brain, damage caused by stroke is reduced and ensuing neurological deficit is lessened. This is believed to be due to magnesium's ability to block calcium from flooding the cells and causing further injury. Decades of research show that withdrawal of magnesium from cerebral arteries cause vascular spasm, whereas elevated magnesium levels produce relaxation (Dean 81). Further research indicates that the area of the brain damaged by stroke contains injured neurons that remain hyperactive for several hours after the stroke has occurred. These cells are frantically struggling to survive and need

even more oxygen, glucose, and magnesium than normal. A study of stroke patients in New York illustrates the absolute requirement for magnesium intervention in the emergency room. Ninety-eight patients admitted to the emergency rooms of three hospitals with a diagnosis of stroke exhibited early and significant deficits in magnesium ions as measured with a sensitive ion-selective electrode. The stroke patients also demonstrated a high calcium-ion-to-magnesium-ion ratio, signs of increased vascular tone and cerebral vessel spasm (Dean 82). Effective conventional stroke treatment can only be given within about a two hour window of time after the stroke has occurred. Sometimes the patients arrive at the hospital too late, and long-term neurologic deficits result. A study conducted in Los Angeles circa 2004, called the Fast-Mag Pilot Trial, demonstrated that field initiation of magnesium in acute stroke is feasible, safe, and potentially efficacious; magnesium prevents cells from being flooded with calcium, thus preventing them from premature cell death. Researchers believe that magnesium slows chemical processes that kill 12 million brain cells per minute during untreated stroke (Sircus 95).

Dr. Bruce Rind and Dr. Sean Dalton developed the RELOX procedure for stroke, an intravenous vitamin mineral solution, with heavy emphasis on magnesium, and the simultaneous application of oxygen by mask. This was administered to 200 patients who suffered aftereffects of stroke from periods ranging from a few days to twenty-plus years. Their results were miraculous. Patients with mild to moderate impairment experienced “moderate to significant, relatively sustained clinical recovery of cognitive, motor, and sensory functions after three 40-minute treatments with no significant adverse effects. Follow-up SPECT scan nuclear imaging of the brain confirmed these improvements (Dean 80). This serves as further evidence that magnesium supplementation, even long after stroke, has a hugely beneficial effect.

Heart disease takes first place as the number one killer of American men and women, and accounts for half of all US deaths. According to the AHA, every thirty-three seconds someone in the US dies of cardiovascular disease. It takes a three-step process for a heart attack to occur: 1) vessel elasticity must be lost; 2) the inflammatory response begins with injury to the arterial wall, which leads to cholesterol and blood cells attempting to patch the damage, and 3) over time, steps 1 and 2 weaken and occlude the coronary arteries and this slowly destroys heart muscle through loss of blood and oxygen supply. Magnesium can help avoid this process. Daily magnesium supplementation can relax vessels and reduce inflammation (Dean 102). Its role as calcium antagonist is emerging: the Agatston score is now being looked to as the new and promising measurement tool for cardiac risk because it measures coronary calcium levels and can more accurately predict cardiac risk far beyond standard risk factors, such as cholesterol levels (Sircus 50). Unfortunately, cardiologists are slow to get on board with magnesium therapy (Sircus 102). It is regrettable, because the evidence is clear: magnesium deficiency is closely related with cardiovascular disease; lower magnesium concentrations have been found in heart attack patients. Magnesium, calcium and potassium are all effective in decreasing blood pressure, and magnesium is especially effective at lowering the odds of death due to acute infarction by an impressive fifty-five percent Additionally, a balanced calcium/magnesium level is essential for a normal heart rate and rhythm, which can also help to avoid heart attack (Dean 113).

OTHER USES AND BENEFITS OF MAGNESIUM

Magnesium has such a monumental overall value in health maintenance and disease prevention, that additional uses and benefit bear at least some examination.

Magnesium and calcium share importance equally in the human body. Biochemically, they act antagonistically toward one another. Enzymes whose actions are critically dependent upon sufficient amounts of intracellular magnesium, in an amount 10,000 times that of calcium within the cell, are adversely affected by tiny increases of intracellular calcium. This relationship takes on special meaning when it comes to conditions which are aggravated by the presence of excess calcium anywhere in the body where it is not designed to be. Magnesium keeps calcium in solution, and magnesium deficiency results in various ailments: Fibromyalgia, muscle spasms, hardening of the arteries, and calcium deposits of all types in soft tissue will result. Excess calcium anywhere in the body, unchecked by adequate magnesium, can accelerate aging of cells and tissues—calcified arteries, soft tissues and cells are all signs of aging. At age 80, the average calcium content in the aorta is 140 times greater than the levels found at age 40. Magnesium relieves mitochondrial calcification, and allows for the production of energy in the body, which has a tremendous benefit for those with low energy states, such as Chronic Fatigue Syndrome, Fibromyalgia, and others (Sircus 51). Kidney stones can form without adequate magnesium, and the bladder wall becomes calcified, leading to frequent urination. Magnesium is present in greater quantity than calcium in all muscles, especially those of the heart and blood vessels. Spasm, constricted blood vessels, angina and heart attack will occur due to an imbalance. Excess calcium can constrict the smooth muscle of the airways, causing restricted breathing or asthma. Without the protection of magnesium, calcium irritates the tiny nerves of the brain (Dean 21). Magnesium is a powerful detoxifier, which gives it great potential for applications in cases of various autoimmune diseases, including cancer, the second leading cause of death (Sircus 85). It not only neutralizes toxins, it protects brain cells from the damaging effects of heavy metals such as aluminum, beryllium, cadmium, lead, mercury and nickel, thus warding off Alzheimer's,

Parkinson's, and other neurologic diseases. Magnesium competes in the small intestine with aluminum; if enough magnesium is present, aluminum cannot be absorbed. It supports the retention of glutathione in the body, which defends against damage from cigarette smoke, exposure to radiation, chemotherapy, alcohol and other toxins. Magnesium relaxes muscles and promotes calm, as an aid to ward off Restless Leg Syndrome and insomnia. And finally, magnesium, along with calcium and phosphorus, works to create and maintain strong teeth and bones (Czapp). It seems there is nothing that the beautiful mineral cannot do.

MAGNESIUM DEFICIENCY IN ALLOPATHIC PRACTICE

With all the emerging research proving the benefits of magnesium to prevent and treat so many illnesses, the question remains: why aren't doctors prescribing more magnesium? The reasons for this are many. First of all, doctors follow a medical model of disease and illness, which requires them to become knowledgeable about diseases and their current drug treatments. Nutrition and supplementation simply does not account for much of their training because they are learning about illness, not wellness. Doctors also have little time to spend in educating their patients about staying well (Dean 39). Original studies on magnesium were poorly controlled, and one study even caused some deaths, which may have caused doctors to generally reject any potential benefits of magnesium (Sircus 113). In addition to this, over the past two decades university funding has come from the pharmaceutical industry (Dean 40). This could indicate a greatly biased focus with regard to what is being taught in medical schools. Huge amounts of pressure is being brought to bear on the government by the pharmaceutical industry: in 2009, Big Pharma lobbying expenses topped out at $273,945,917 (opensecrets.org). The public is inundated with commercial advertising for pharmaceuticals, perhaps to cause a cultural revolution in favor of pharmaceuticals, the industry having spent a whopping $5.2 billion on

drug promotion. In contrast, nutrients, which are not patentable; they do not make huge profits, generate a budget, or get much media attention (Dean 40). Dr. Sarah Myhill states:

> There have been many studies showing that magnesium is clearly beneficial in heart disease. The trouble is the drug companies do not want to know. Magnesium is a serious competitor to their money-making pharmaceuticals. And so they set up a study [in which study patients died from magnesium doses ten times the accepted dose] to deliberately blacken the name of magnesium (Sircus 114).

Within the looming shadow cast by an overblown and autocratic pharmaceutical industry, a persistent grass roots effort is critical to substantially raise public awareness regarding the benefits of magnesium in order for change to occur.

MAGNESIUM TESTING: A COMPARISON OF OPTIONS

When looking for testing for magnesium deficiency, it is not as simple as just going to the doctor or the lab. The reason for this is that there may be some misunderstanding in the medical community when a patient requests a magnesium test. To determine the best type of testing for magnesium deficiency, it is best to understand where magnesium typically resides in the body. Magnesium is present in certain areas of the body in specific amounts. About 60 to 65 % of total magnesium is housed in the bones and teeth. Roughly 35 to 40% of total magnesium is found in electrically active areas, such as the brain and heart, and in the rest of the body, including muscles, tissues, cells and body fluids (Dean 14). But, despite all the metabolic processes which rely on magnesium, less than 1 percent of the total magnesium body content can be measured in blood; the remainder is at work in the cells and tissues or maintaining structural integrity of the body. As a result, it is nearly impossible to make an accurate assessment of the level of

magnesium in various body tissues and cells by using a routine serum magnesium test. This test is often called a Total Serum Magnesium test, which sounds as if it relates to all the magnesium in the body. This, however, is not the case. Magnesium in the blood does not correlate with the amount of magnesium in other parts of the body. In fact, while influenced by stress due to illness, the body pumps magnesium out of the cells and into the blood, giving a false-normal result on testing in spite of an overall depletion. Unfortunately, most magnesium evaluations done in conventional medicine use the antiquated Serum Magnesium Test (Dean 218).

The Intracellular Free Magnesium test is a nuclear magnetic resonance spectroscopy test which has little routine use and great cost, which renders it impractical. Magnesium Loading, or Challenge, consists of a 24-hour urine test on two separate occasions. The first urine collection is performed with the patient taking their normal supplementation regimen. Then, an intravenous infusion in an amount of 2 milliequivalents per kilogram of body weight of magnesium chloride or magnesium sulfate is given over a four hour period. A second urine collection begins after the I.V., and every urine sample is collected for twenty-four hours. Deficiency is noted when the body holds on to more than twenty-five percent of the magnesium given. This test is best used for the rare persons who may be wasting magnesium (Dean 220). The Ionized Magnesium Test which measures available free magnesium ions in the blood and is very accurate because the measurement of active ions in the blood gives a reliable accounting of the actual magnesium at work in the body. However, it requires expensive lab equipment which is not available at most sites, and is therefore reserved for research use (Dean 222).

Two of the most available assays are the Buccal Cell Smear Test (EXATest) and the Total Red [Blood] Cell Magnesium Test (MgRBC). In the EXATest, cells are gently scraped from between the bottom teeth and the back of the tongue. This is performed at a doctor's office,

and gives an accurate measurement of the amount of magnesium in the cells of the body. It is expensive, but may be covered by Medicare or other insurance. The MgRBC measures the amount of magnesium inside the red blood cells. More accurate than the serum test, but less accurate than EXATest, it is a good option because it can be ordered over the internet if a person is unable to obtain a prescription. The cost is about $50, a ZIP code must be provided, and the service will arrange the blood draw at a local lab. Results are available within 72 hours. Dr. Dean recommends that this test be done as a baseline, and levels should be rechecked every three to four months. Normal ranges for this test are as follows:

Magnesium Test	**mg/dl**	**mmol/L**	**mEq/L**
MgRBC	4.2-6.9	2.4-2.57	3.37-5.77

Three units of measure are provided, as unit of measure used may vary by lab (Dean xxxviii).

MAGNESIUM REQUIREMENTS

It has been presented that magnesium deficiency is a condition which has been precipitated by our modern existence. In fact, the factors which cause magnesium deficiency are varied and numerous. Stressors alone use up large amounts of magnesium in the body. It has been argued by magnesium experts that the Recommended Dietary Allowance (RDA) for magnesium should be increased (Dean 216). Table 3 provides the most current RDA information available.

Table 3. 2016 RDA (consumerlab.com)

2016 RECOMMENDED DIETARY ALLOWANCES FOR MAGNESIUM					
Life Stage	**Children**	**Men**	**Women**	**Pregnancy**	**Lactation**
Age 1 – 3 years	80mg	N/A	N/A	N/A	N/A
Age 4 – 8 years	130mg	N/A	N/A	N/A	N/A
Age 9 – 13 years	240mg	N/A	N/A	N/A	N/A
Age 14 – 18	N/A	410mg	360mg	400mg	360mg
Age 19 – 30	N/A	400mg	310mg	350mg	310mg
Age 31+	N/A	420mg	320mg	360mg	320mg

MAGNESIUMS SOURCES

Food. Green, leafy vegetable, seeds, tree nuts and whole grains are good sources of magnesium, but only if they come from a well-mineralized farm. Wild foods, such as nettles (869mg per 100 grams) and chickweed (529mg per 100 grams) have great benefits for humans and livestock. Kelp stands out with other sea vegetables as having the highest content of magnesium because they are continually drenched in sea water, which is also high in magnesium. Sea salt is also a good source of magnesium, as well as trace minerals (Czapp). Bone broth taken on a daily basis is as easily assimilated source of many minerals, including magnesium (Dean xl). Additionally, legumes and unprocessed grains should be included in the diet to increase magnesium intake. Grains must be unprocessed, because removal of the germ and bran eliminates most of the magnesium which is present in the whole grain. It is recommended to supplement a diet consisting of vegetables, fruits, and protein-rich foods such as fish, meat, and milk by eating wheat germ, kelp, brewer's yeast, sunflower seeds, and pumpkin seeds, which are all rich in magnesium. More raw foods should be eaten, as cooked and processed foods are mineral-poor. Nuts, seeds, and many vegetables can be eaten raw, and raw wheat germ can be used on cereal and in protein drinks (Dean 227).

To protect heart and blood vessels, reduce saturated fats, increase monounsaturated fat and omega-3 fatty acids (found in fish and flaxseed), cereals, fruits, vegetables, and low-fat dairy products, which are rich in magnesium. Alcohol should be limited. Table 4 lists the magnesium content found in common foods.

Table 4. Magnesium Content of Common Foods (Dean 255)

MAGNESIUM CONTENT OF COMMON FOODS			
Food	**Magnesium (mg) per 3 ½ oz. (100g) serving**	**Food**	**Magnesium (mg) per 3 ½ oz. (100g) serving**
Kelp	760	Parsley	41
Wheat bran	490	Prunes, dried	40
Wheat germ	336	Sunflower seeds	38
Almonds	270	Barley	37
Cashews	267	Beans, cooked	37
Molasses	258	Dandelion greens	36
Yeast, brewer's	231	Garlic	36
Buckwheat	229	Raisins	35
Brazil nuts	225	Green peas, fresh	35
Dulse	220	Potato with skin	34
Filberts	184	Crab	34
Peanuts	175	Banana	33
Millet	162	Sweet potato	31
Wheat grain	160	Blackberry	30
Pecan	142	Beets	25
English walnuts	131	Broccoli	24
Rye	115	Cauliflower	24
Tofu	111	Carrot	23
Coconut meat, dried	90	Celery	22
Brown rice	88	Beef	21
Soybeans, cooked	88	Asparagus	20
Figs, dried	71	Chicken	19
Apricots	62	Green pepper	18
Dates	58	Winter squash	17
Collard greens	57	Cantaloupe	16
Shrimp	51	Eggplant	16
Corn, sweet	48	Tomato	14
Avocado	45	Milk	13
Cheddar cheese	45		

Oral and Transdermal Supplements. Given ideal conditions of digestive functions and quality food supply, only a small amount of magnesium taken in food will be absorbed. Magnesium is better absorbed when the body is deficient; however, since limited magnesium can be obtained from foods, supplementation is crucial. Certain people—those with advanced kidney disease,

extremely slow heart rate, Myasthenia Gravis, or bowel obstruction—should avoid magnesium supplementation. About 3 to 10 milligrams per pound of body weight, depending upon physical condition, growth requirements (in children), and degree of symptoms, is recommended (Czapp, Dean 240). Specifically, the rule of thumb recommended to individualize magnesium dosage is 6 to 8 mg/kg (3.0 to 4.5 mg/lb) of body weight per day. This equals total dietary and supplemental magnesium of 600 to 900 mg per day for a 200-lb man. Researchers recommend 10 mg/kg/day for children due to their low body weight and increased growth needs. Athletes need 6 to 10 mg/kg/day, depending on training levels and physical stress. With supplementation, periodic testing to reach the optimum blood level of 6.5 mg/dl is a sure way to correct magnesium levels (Dean 240). Rates of magnesium absorption by oral supplementation vary from 4 to 50 percent, depending on type and absorption ability (Dean 241). Some forms of magnesium work better for some than for others, and a bit of experimentation may be needed. Loose stools are a failsafe mechanism which occurs if magnesium is being poorly absorbed, or if too much is taken. If this is the case, partial doses may be taken in early morning and at bedtime; if a third dose is needed, then it should be taken in late afternoon. These times coincide with when the body is lowest in magnesium (Czapp). Magnesium should be taken between meals, because it needs plenty of stomach acid for better absorption. People with gas and bloating problems may have insufficient hydrochloric acid in the stomach, and may need to take magnesium with a digestive aid, such as betaine hydrochloride, to help absorb minerals (Dean 247). Also, if magnesium supplementation has never been tried before, or the individual has multiple symptoms which indicate a fair amount of deficiency, it is best to start low and increase the dose: suddenly flooding the body magnesium may cause a healing crisis (Dean xlv).

There are many magnesium supplement options to choose from, for all purposes and pocketbooks. Magnesium is available in tablets, capsules, powder, salts, and liquid oral and (in healthcare facilities) I.V. forms. Magnesium can be chelated, or bound to an amino acid, for less laxative effect. Magnesium taurate, glycinate, and orotate are all amino acid chelates of magnesium. Magnesium taurate is particularly helpful for heart health. Magnesium supplements can be in picometer form, which means that the magnesium particles are in a tiny, ionized form, similar in size to plant magnesium. This type of magnesium supplement is highly absorbed with no bowel effect, but tends to be quite expensive. Magnesium malate contains magnesium weakly bonded to malic acid. It is readily soluble, and malic acid is an important component in several energy-producing processes, making this a good supplement for those with Chronic Fatigue Syndrome and Fibromyalgia. Magnesium chloride, available in capsules, powder, picometer (and I.V.) forms, is best for those with insufficient stomach acid, or who take antacids. The chloride in this form actually helps to produce more hydrochloric acid in the stomach (Dean 241-246).

Magnesium citrate is the most widely used magnesium supplement, due to only minor laxative effect and because it is inexpensive. It is also widely available in drug stores, as a 12,000 mg dose of this liquid is routinely ordered by doctors for a bowel purge prior to colon exams. At health food stores, it is also available in powder or capsule form (Dean 242). Also, for people with absorption difficulties such as reduced stomach acid or gut dysbiosis, homeopathic Magnesia phosphorica 6X cell salt is an option which should be considered. It helps magnesium get directly into the cells where it is most needed, relieves muscle cramps, and reduces or eliminates loose stools while other oral supplementation is taken. Another option is ionic liquid magnesium: just one teaspoon delivers 400 mg of magnesium plus 72 other minerals. This should be taken in divided doses through the day (Czapp).

An adjunct therapy is transdermal magnesium supplementation. Oral magnesium must reside in the intestine for at least 12 hours for reliable absorption (Sircus 156). Magnesium taken through the skin bypasses the stomach and liver, which translates in into a greater percentage of magnesium going directly into the bloodstream for use. Also, there is no bowel effect via this route. Transdermal magnesium is excellent for pain management, and magnesium chloride, commonly known as Epsom salts, in a bath draws inflammation out of muscles and joints (Sircus 151). Transdermal absorption rates can vary widely, though. Fick's Law of Membrane Permeability states that "the amount of solute (magnesium) that will be absorbed is directly dependent upon the area of contact, the concentration of the solution and the time that the solute is in contact with the membrane" (Sircus 160). The condition of skin, whether thin or thick, and the size of the skin surface exposed to magnesium will vary the dose. Epsom salts product labels recommend using 2 cups per bath; Dr. Sircus recommends using several cups to several pounds of Epsom salts in very warm water, one to three times per week for 20 minutes (Sircus 181). Strong therapeutic foot soaks can be taken, and are especially good for diabetics with neuropathy. Product labels recommend using ½ cup of Epsom salts in a foot bath; Dr. Sircus recommends to use 108◦F water and start with this low amount of magnesium and increasing the concentration. Therapeutic foot baths can be taken daily for the first week, then two to three times weekly for at least 6 to 8 weeks to improve neuropathy (Sircus 162).

Pure magnesium oil spray has a concentration of about 80,000 mg per liter; when sprayed on the skin, the intake rate is high. Each spray of magnesium oil contain roughly 18 mg of elemental magnesium, and 5 sprays equal nearly 100 mg (Sircus 160). Side effect of the spray oil is a transient tingling or mild burning sensation of the skin. If this is too uncomfortable, it should be diluted with water at a 1:1 ratio (Sircus 181). Both Epsom salts baths and magnesium

oil application should be adjusted downward for children depending on their age and size (Sircus 161). As with all therapeutic use of magnesium, it is best to monitor levels with periodic testing.

CONCLUSION

Magnesium is a safe, effective, inexpensive, non-polluting and natural treatment for ailments of all types. Taken orally and transdermally, it can help most anyone to achieve a higher level of natural health. Magnesium can achieve therapeutic reversal of conditions through nutritional support while conventional medicines only work in terms of symptoms management at the cost of wasting precious body resources. In the naturopathic field, we must do all we can to help educate doctors, the agricultural sector, and most especially, the consumer public as to its wellspring of health benefits. Magnesium is truly the most beautiful mineral.

Magnesium: The Beautiful Mineral

http://www.pnnl.gov/news/images/photos/20130918191805298.jpg

Appendix

100 risk factors in 68 categories showing magnesium deficiency (Dean 17-20):

1. Alcohol intake—more than seven drinks per week
2. Anger
3. Angina
4. Anxiety
5. Apathy
6. Arrythmia of the heart
7. Asthma
8. Blood tests
    a. Low calcium
    b. Low potassium
    c. Low magnesium
9. Bowel problems
    a. Undigested fat in stool
    b. Constipation
    c. Diarrhea
    d. Alternating constipation and diarrhea
    e. IBS
    f. Crohn's
    g. Colitis
10. Brain trauma
11. Bronchitis, chronic
12. Caffeine (coffee, tea, chocolate), more than three servings per day
13. Chronic fatigue symdrome
14. Cold extremities
15. Concentration difficulties
16. Confusion
17. Convulsions
18. Depression
19. Diabetes
    a. Type I
    b. Type II
    c. Gestational diabetes
20. Fibromyalgia
21. Food intake imbalances
    a. Limited in green leafy vegetables, seeds, and fresh fruit
    b. High protein

22. Food cravings
    a. Carbohydrates
    b. Chocolate
    c. Salt
    d. Junk food
23. Gagging or choking on food
24. Headaches
25. Heart disease
26. Heart—rapid rate
27. High blood pressure
28. Homocysteinuria
29. Hyperactivity
30. Hyperventilation
31. Infertility
32. Insomnia
33. Irritability
34. Kidney stones
35. Medications
    a. Digitalis
    b. Diuretics
    c. Antibiotics
    d. Steroids
    e. Oral contraceptives
    f. Indomethacin
    g. Cisplatin
    h. Amphotericin B
    i. Cholestyramine
    j. Synthetic estrogens
36. Memory impairment
37. Mercury amalgam dental fillings
38. Menstrual pain and cramps
39. Migraines
40. Mineral supplements
    a. Take calcium without magnesium
    b. Take zinc without magnesium
    c. Take iron without magnesium
41. Mitral valve prolapse
42. Muscle cramps or spasms
43. Muscle twitching or tics
44. Muscle weakness
45. Numbness of hands or feet
46. Osteoporosis
47. Paranoia
48. Parathyroid hyperactivity
49. PMS
50. Polycystic ovarian disease

51. Pregnancy
    a. Currently pregnant
    b. Pregnant within one year
    c. History of preeclampsia or eclampsia
    d. Postpartum depression
    e. Have a child with cerebral palsy
52. Radiation therapy, recent
53. Raynaud's syndrome
54. Restlessness
55. Sexual energy diminished
56. Shortness of breath
57. Smoking
58. Startled easily by noise
59. Stressful life or circumstances
60. Stroke
61. Sugar, high intake daily
62. Syndrome X
63. Thyroid hyperactivity
64. Tingling of hands or feet
65. Transplants
    a. Kidney
    b. Liver
66. Tremor of hands
67. Water that contains the following
    a. Fluoride
    b. Chlorine
    c. Calcium
68. Wheezing

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