IS IT POSSIBLE TO BE HEALTHY AND PHYSICALLY FIT AT 100?

My personal reasons for writing this essay include considerable anger and frustration. Anger over spending so much time reading labels, while grocery shopping, to be sure I am not poisoning my family. Anger because I now know how bad many of the things I love, like cheesecake, really are for me. Frustration because many of the things the media has alerted me to avoid in the past (like liver, eggs, red meat, olive oil, avocados, butter, wine and etc.) became "healthy" things to consume six months, a year or two years later. Frustration because everywhere I look there is yet another new gimmick or drug offering yet another quick or easy way to lose weight, and "keep it off", while more and more Americans seem to be losing the "battle of the bulge". Finally, as someone who **LOVES** cooking/ preparing novel, appealing and nutritious meals, I am both angered and frustrated that so many 'others' at my dining room table are suffering from high blood pressure, Type II diabetes, arteriosclerosis and other 'poor dietary habit-related' health problems. I can no longer plan a meal for my family or friends without first worrying that something I might serve them could shorten their life. I guess that means I feel especially angry and frustrated because we are all being forced into two equally repugnant roles: (1) being the 'food police' for those we love and care about, or (2) being someone who is aiding and abetting the self-destructive and 'poor eating' habits/ behaviors of those we truly value.

If you share my anger or frustration, or long for those easier and better times when you didn't worry about shortening your life or someone else's just because you had prepared or served a tasty meal, please read this essay. If you don't understand it after reading it once, please read it again, and perhaps even for a third time. I discovered, several decades ago, that things that seem incomprehensible the first time you read them, begin to make sense on the second reading, and by the third reading, you can't figure out why they ever seemed hard to understand in the first place. Feel free to contact me if you remain confused after that third reading. My goal in writing this essay was to share with you the nutritional "keys" necessary for living a long, active and vital life, not just the keys to staying alive.

Nutrition and Bone Health Information for Adults (50+): Part I-Calcium

Although more than two dozen vitamins and minerals are known to perform a wide variety of functions essential to normal growth and health in the human body, only three are critical for the health of your bones: calcium, vitamin D and vitamin K. We all know calcium is an essential building block of strong bones, but most of us do not know we also need vitamins D and K to open the "doors" that allow us to get calcium out of our digestive system and into our bones. Because the average daily intakes of all three of these essential bone nutrients are inadequate in the USA, there is growing concern about the skeletal health of all Americans, young and old [1].

Calcium: What is it?

Calcium is the most abundant mineral in the human body. In healthy children and young adults, 99% of this calcium is stored in their bones and teeth where it functions to support their structure. The remaining 1% is distributed throughout the body, in blood, muscle, and the fluids in and between every cell in our body. In both children and adults with poor dietary and activity habits, significant deposits of harmful calcium salts also occur in the kidneys (as kidney stones), blood vessels (as plaque that causes "hardening of the arteries), eyes (as deposits that can cause cataracts and glaucoma) and intestines (as hard masses that can lead to bowel obstructions) [2].

The amount of calcium circulating in your blood is kept within a very narrow range at all times. This is because your blood won't clot, your muscles (including your heart) won't contract or relax, and the muscles of your blood vessels won't be able to move blood around your body unless their needs for calcium are being met. You won't be able to remember, think, learn or feel if the cells in your brain and peripheral nervous system are deprived of calcium. In fact, the over 170 different roles calcium plays in all the non-skeletal parts of your body are so critical to your survival that you "borrow", and will keep borrowing, calcium from your bones and teeth to meet these 'other' needs whenever you are not getting enough calcium from the foods you eat or supplements you take. In the USA, only 45% of men and 22% of women over the age of 20 are currently getting enough calcium from their diet and/ or supplements to maintain a healthy skeleton throughout their lifespan. So, exactly why is it that the majority of your relatives, friends and neighbors aren't paying more attention to how much calcium they consume? Even though it would be nice if there was, there is no one simple or easy answer to this question [3].

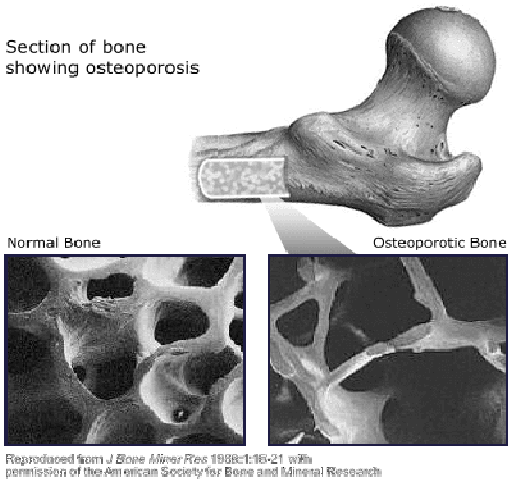
Bones are living tissues that undergo a continuous, but relatively slow process of "remodeling". What our bones are doing, continuously, day in and day out, during their 'remodeling' is a lot like what we do when we remodel our homes, provided we are living on a fairly tight budget. Our bones fix or repair their existing structural problems, and then they make improvements. If we go back to the home-remodeling analogy, our bones never put on an addition before they first repair the foundation and roof. They never add onto something before making it strong enough to bear the extra weight [4].

So, we can't fault our bones when their non-stop remodeling eventually leads to osteoporosis. We can only fault the lifestyle choices we each voluntarily and consciously make, day after day. It was not our genes, but rather what we each chose to eat and how active we each chose to be, that prevented our bones from remaining the superior 'structural remodelers' they were genetically-programmed to be. More often than not, it is the unwise lifestyle choices we each make, not our genes, that lead to our developing either osteopenia or osteoporosis as we age.

'Bone remodeling' removes calcium from existing bone (bone resorption/ break down) and deposits calcium into newly-formed bone (bone formation). During childhood and adolescence, this remodeling allows our bones to grow, become stronger and repair themselves. As adults, it allows our bones to repair defects and tiny breaks (often called 'hairline', fatigue or stress fractures) we may not even know exist, as well as the major breaks that require medical care [5].

The balance between the rates at which old or damaged bone is being broken down and new bone is being formed changes as we age. During childhood and adolescence, more new bone is being formed and less old bone is being broken down. This allows bones to grow and become stronger. In early and middle adulthood, these processes are relatively equal. "Peak bone mass", the point when the maximum amount of bone is achieved, is typically reached by age 30. [NOTE: People who eat a healthy diet and exercise daily can continue to increase their peak bone mass until the age of 45.] The extent and rate of this bone loss depends on the dietary and other lifestyle choices each person makes. For all older adults, especially post-menopausal women, bone resorption will exceed its formation, and result in bone loss, unless everything is being done to maximize **calcium absorption** and to minimize **calcium excretion**. Today, one in five American women between the age of 50 and 59, and over half over the age of 80 have lost this battle and suffer from osteoporosis (see diagram below) [6].

Are older men exempt from this risk? Absolutely not! The genes of men predispose them to have stronger (denser) bones than women. But after the age of 60, men and women fight identical battles to minimize their bone loss. Many seniors joke about the fact that they are "shrinking", but never realize their bones became less dense and more fragile long before they "shrank" [7].



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What affects your body's ability to absorb calcium from the food you eat?

Calcium absorption refers to how much of the calcium in the foods you eat (or the supplements you take) makes it from your digestive system (gut) into your blood. **Calcium excretion** refers to the amount of calcium that leaves your body in your feces, urine and sweat. The bottom line that you should never forget is whenever the amount of calcium leaving your body is greater than the amount of calcium you put into it, calcium is being lost from your bones and teeth. So, if you don't want your bones to look like the osteoporotic bone shown above, or even if some of your bones already do, please "hear" the important information contained in this essay. The single most important message for anyone reading this essay is that every cell in your body requires **calcium**, **vitamin D** and **vitamin K**, but always all three, each in adequate supply, to insure you will be healthy and fit at 100. The other message, perhaps an even more important one for everyone over the age of 65, is one of hope: Even if your bones now look more like the image on the right than the one on the left, no matter how old you are, it is still within your power to prevent the situation from getting worse, and may even be possible to reverse it, simply by eating better and becoming more active [8].

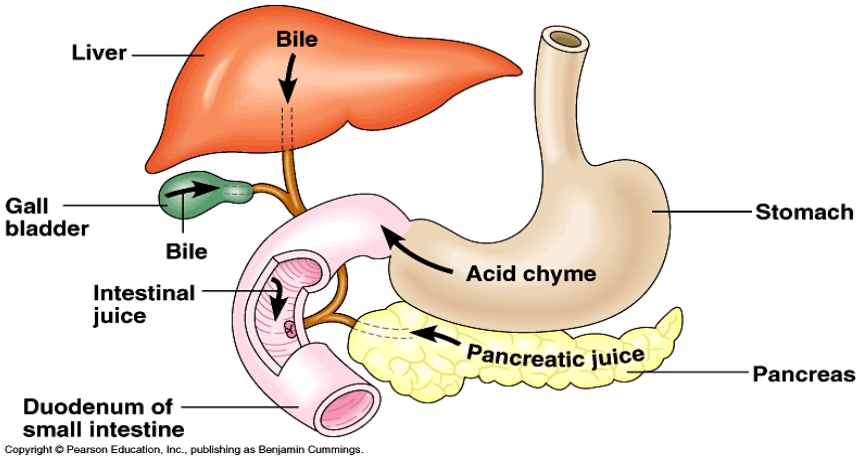
Calcium absorption is affected by how much and what you eat, your age, your reproductive status, your vitamin D status and your vitamin K status. Calcium passes out of your stomach and is either absorbed by cells lining the "walls" of the intestines, or stays in the intestines and passes straight through your body. For dietary calcium to be absorbed, it must be actively removed from the intestines or passively 'escape'. Calcium is actively removed from the intestines by several mechanisms. The first involves vitamin D-dependent 'ionic calcium' transport. We really don't need to understand this active calcium transport mechanism beyond knowing that it is analogous to a situation where you pre-package something you need to ship and then personally load the package onto the next express train going to the most appropriate destination [9].

The second vitamin D-dependent mechanism is one of the fastest and most efficient pumping mechanisms in your body. It pumps calcium from the food you just ate, after it leaves your stomach and enters your small intestine, into your bloodstream in approximately two minutes. Even though I can't describe anything similar to packing a bag and putting in on an express train to explain this "pumping" mechanism, please believe me when I insist your body benefits greatly from this extremely rapid infusion of calcium into your bloodstream [10].

A third, vitamin D-independent, mechanism also allows you to absorb calcium from the food you eat or the supplements you take: passive diffusion. During passive diffusion, calcium passes into

the cells lining your intestines, or through the spaces between these cells (Passive diffusion: If you drop a red candy into a glass of hot water and just let it be, first it dissolves and eventually it "passively diffuses" throughout the glass, turning the water a uniform reddish color.). As you probably already realize, passive diffusion is the slowest and least efficient form of calcium absorption your intestines utilize [11].

Approximately 90% of the calcium you absorb from the foods and supplements you consume occurs in the first third of your small intestine, the duodenum. The duodenum is only about 10 inches long (see diagram below). This is also where 90% of the highly efficient and rapid vitamin D-dependent active transport and "pumping" of calcium out of your intestines occurs (the remaining 10% occurs in the first third of the large intestine) [12].



Meal size: Calcium absorption in your gut depends on how much food you eat in a meal. Using a glass of milk as an example, less calcium is absorbed from a glass of milk when it is the only thing you consume, than from a glass of milk consumed as part of a small meal. But far less calcium is absorbed when that same glass of milk is consumed as part of a large meal. How much you eat is critical because it determines how long food remains in the duodenum where vitamin D-dependent mechanisms rapidly move calcium from your intestines into your blood. In contrast, the passive mechanisms that act throughout the intestines are slow and relatively inefficient. [We briskly stir the teaspoon of sugar we add to our coffee because 'passive diffusion' would take too long to sweeten our cup of coffee.]. Passive diffusion in our intestines is also a two-way street. Calcium moves just as easily out of our blood, and into our intestines [13].

How much calcium we put into our bodies at any one time (e.g. a supplement or a glass of milk) also affects its absorption. **More is not better**. Specifically, less and less is absorbed after the amount of calcium we take in exceeds 500 mg (approximately the amount of calcium in 8 ounces of plain low fat yogurt or one Viactiv® chew). Because this is true, it is very important for your bone health that you spread your calcium intake across the day. This "500 mg is best" effect occurs because the very efficient vitamin D-dependent mechanisms get "shut off" when your 'at any one time' calcium intake exceeds 500 mg. Once this happens, you become largely dependent on passive diffusion mechanisms to meet your calcium needs, which is not an especially good idea [14].

It can't be over stressed just how important optimizing the vitamin D-dependent calcium transport and pumping mechanisms are to bone health, especially in the elderly. In order to optimize them, one needs to enjoy an optimal **vitamin D** status and optimal **vitamin K** status, in

addition to optimizing their dietary calcium intake. Two hundred years ago, one could achieve all three of these optima simply by living a normal life. Today, achieving them requires considerably more effort than just 'normal living'. Why? Critical things about our planet and the way Americans utilize their resources have changed. These "things" won't be discussed here, but are explained in more detail later in this essay [15].

Food type-Dairy: Milk and dairy products are the most common sources of dietary calcium for most Americans. However, it should be noted that dairy products are not the only good sources of dietary calcium. Tap water can even be a major dietary source of calcium, if your water is very "hard". Dentists have noted the benefits of drinking "hard" tap water for decades. Persons growing up in areas of the USA where there are high levels of calcium in the water they pump from their backyard artesian wells or springs have stronger teeth and fewer cavities as adults than people 'raised' on calcium-poor drinking water. Also, the tooth health of the Irish declined after they replaced their previously very high dietary intakes of potatoes with white bread. Unfortunately for your bones and teeth, many home filtration devices, including all *ion exchange systems* (also known as water softener systems), eliminate calcium from hard water [16].

For 90% of the world's adult population, and approximately 25% of adult Americans, milk is not even a viable source of calcium because they are '**lactose-intolerant**'. Although the majority of Americans of European heritage tolerate milk well, 70-95% of Asian, African, Middle Eastern and Native American heritage do not. Milk-intolerance occurs in adults who do not produce lactase, an enzyme that breaks down milk sugar (lactose) into simple sugars that are easily absorbed. Undigested lactose irritates the intestines and acts as a laxative, leading to poor absorption of many essential nutrients, including calcium. Adults (and in rare cases infants or preadolescent children) who are lactose-intolerant will begin developing classic symptoms (nausea, stomach or intestinal pains, bloating, gas and diarrhea) between 30 minutes and two hours after consuming dairy products. [NOTE: When infants develop the symptoms of lactose-intolerance (their 'spit up' smells sour, they are fussy or cry a lot and have frequent loose stools or diarrhea that will lead to diaper rash if their diapers are not changed immediately) soon after breast feeding or drinking infant formulas, it is very important to have them evaluated for a lactase deficiency. Like all forms of animal milk, breast milk and most commercial infant formulas contain relatively high levels of lactose] [17].

Fruits, Vegetables, Nuts and Grains: Some fruits, vegetables, seeds, nuts and grains are also good sources of calcium. However some naturally-occurring plant substances, most notably oxalate, phytate and fiber, can bind calcium and prevent it from being absorbed. Oxalate is the most potent plant-derived inhibitor of calcium absorption known. It is found in high concentrations in beets, spinach, swiss chard, star fruit and rhubarb, and in somewhat lower concentrations in collard greens, okra, sweet potato, figs and dried beans (including soybeans). While we generally absorb up to 27% of the calcium in a glass of low fat milk, only 5% of the calcium in a serving of cooked spinach or rhubarb is absorbed [18].

Phytate is a less potent inhibitor of calcium absorption than oxalate. It is found in grains and dried beans. Because yeast breaks it down in bread, only concentrated sources of phytate such as wheat germ, wheat bran (e.g. cereals like All Bran®), or dried beans substantially reduce calcium absorption. Other foods high in phytate include seeds, nuts and soy products (including soy milk which is also high in fiber and oxalate). This means lactase-treated dairy products (e.g. Lactaid 100®), animal milk-derived hard cheeses (which contain very little lactose because almost all of the lactose in milk is in the "whey" which is removed before manufacturing hard

cheeses), and yogurts or cottage cheeses with "live and active cultures" (the bacteria in these cultures pre-digest lactose for you) are generally better sources of calcium for milk-intolerant individuals than calcium-fortified soy milk. However, lactose-intolerant people do need to be more vigilant than others about reading the labels on the packaged foods they buy. The "whey' removed from hard cheese is not thrown away, but added to soft cheeses, cake, pancake and muffin mixes, breads and cereals, muscle-building supplements, etc. [19].

It is **very** important to point out that few Americans consume enough fiber to interfere with their calcium absorption. Oxalate and phytate only interfere with calcium absorption from the food sources where they co-occur, not calcium from other food sources consumed at the same time. Furthermore, soaking foods high in phytates in cold water for two hours, and then draining off the water, eliminates the calcium-binding properties of these foods. Therefore, one should **never** avoid eating foods that are high in fiber, oxalate or phytate, only not include the calcium they contain when calculating one's daily dietary calcium intake. The one exception to this rule applies to anyone predisposed to developing kidney stones. They should avoid all food sources high in oxalate [20].

Fish and shellfish: All types of fish, especially when their soft bones are consumed, are also good sources of calcium. Evolutionary scientists believe our European ancestors originally developed the mutation that first allowed them to digest the lactose in animal milk less than 10,000 years ago. Prior to that time, the soft bones of fish and very young animals probably provided a significant source of dietary calcium for all humans. Even today, in many poor, under-developed parts of the world, they still do. Many types of canned seafood (sardines, salmon, crab, lobster, mackerel etc.) are excellent sources of calcium because they contain fish bones or crustacean "shells". These bones or shells are softened by the heating process used to make canned seafood safe to eat [21].

Weeds: Many common garden weeds also contain calcium. In fact, a cup of 'young' lambsquarters' leaves (a very edible weed – see picture, top of next page) contains almost three times as much calcium as a glass of whole milk. All animals, even cows, must get calcium from the foods they eat. Household pets that are deficient in calcium will eat grasses, gnaw on bones (dogs) or eat small animals (cats), bones and all, if their dietary calcium needs are not being met by the pet foods you are feeding them. If you want to stop your family pet from "grazing" in your flower beds or on your lawn, you might consider giving it the salad or vegetable leftovers from your lunch or dinner [22].

'Lambsquarters' when it is most edible

Wild animals "naturally" eat diets rich in calcium and rarely develop osteoporosis. These same "wild" animals will develop osteoporosis in zoos, unless they are given calcium supplements or fed foods rich in calcium. This is, unfortunately, not the case for the turkeys our Presidents "pardon" each Thanksgiving. Most get put to sleep soon after being "pardoned" because they already have osteoporosis so advanced that their legs rapidly become unable to support their body weight. NASA, oddly enough, has found a way to prevent further bone (and muscle) loss in

domesticated turkeys (and humans): vibration therapy (see picture below). [FYI: Vibration therapy helped to prevent both bone and muscle loss in virtually every sedentary (largely inactive) animal species where it has been studied. So, if one of your children or grandchildren gave you a vibrating chair, vibrating chair cushion or foot massager for your birthday or some other special occasion, you really should consider using it on a regular basis.] [23]

Photo credit: Cary Wolinsky. This image originally appeared in a National Geographic feature article "Surviving in Space."

Scientists believe many fruits, vegetables and nuts once contained levels of calcium similar to those found in cow's milk today, perhaps as recently as 100 years ago. The very same 'modern' farming techniques that created America's "dust bowl" (specifically poor crop rotation and over-reliance on commercial fertilizers), sharply depleted much of the naturally-occurring calcium in our soil. According to the US Department of Agriculture, the calcium content of most fruits and vegetables dropped 30-50% between 1930 and 1990. Since 1990, this situation has begun to reverse itself [24].

Low magnesium limestone (calcium carbonate, the same form of calcium in Tums®) is now being applied in both the late fall and early spring in an effort to increase the calcium available to plants from soil. Even so, when plants are over-fertilized as they start growing, most of this replenished calcium goes to their stems and leaves, and stays there. When this happens, insufficient calcium is available for the "fruit" and blossom-end rot results. Tomatoes, beans, peas, squash, cucumbers, potatoes and perennial fruits (like strawberries, currants, raspberries and avocados) are especially susceptible to calcium deficiency during the blossom stage. It seems a bit ironic that simply because plants, just like humans, have strict requirements for a steady diet of nutrients (in balance with each other) for their optimal growth and health, the calcium contents of the fruits, vegetables and nuts we typically eat are now on the rise [25].

Fats, Protein and Sodium: Finally, any food sources high in saturated fats, meat protein and/ or sodium also inhibit calcium absorption. These potential dietary calcium-cannibals include most processed (e.g. hotdogs, bologna, bacon and etc.), "ready-to-eat" (frozen and dehydrated) meals, canned soups, "fast foods" and most (but not all) restaurant meals. [FYI: A single "fast food" meal consisting of a Burger King Bacon Double Cheeseburger, king sized fry and glass of whole milk exceeds the total fat, saturated fat, protein, and sodium requirements of women for the entire day.] However, I am willing to bet that not a single person who orders a Burger King, MacDonald's or Kentucky Fried Chicken "extra value meal" ever considers they are about to consume the dietary equivalent of stirring two eggs, several tablespoons of liquid detergent and several tablespoons of salt into a glass of milk. This is essentially what they are doing because calcium complexes with saturated fats to form insoluble calcium-soaps that can't be absorbed. It also complexes with the sulphur (think about the smell of rotten eggs) and phosphorous in proteins to form insoluble salts. Finally, the high sodium concentrations in most "fast foods" block the absorption of a number of important nutrients, including calcium, by causing the cells lining the gut to swell. The 'Standard American Diet' (ironically, or perhaps aptly, it has the

acronym of 'SAD') has five times the sodium your body needs. While fats, proteins and sodium can decrease calcium absorption, their more damaging effects, for bone health, are on calcium excretion/ loss (these additional "bad" effects are not explained here, but are covered in the section on **calcium excretion**) [26].

Because cows' milk has relatively high concentrations of sodium (~120 mg per 8 ounces) and isn't well tolerated by many adults, many fruit juices (which are relatively low in sodium: 5 mg per cup for orange and cranberry juice, 7-8 mg for apple and pineapple juice) are now being fortified with 300-500 mg of calcium (300 mg = the amount of calcium present in a glass of low fat milk; 500 mg = the amount present in most 8 ounce low fat yogurts). Research indicates the calcium in fruit juices is significantly better absorbed than the calcium in milk (this is also true of the vitamin D added to juices). When meal size is optimal and calcium intakes are equivalent, approximately 27% of the calcium in low fat milk is absorbed, while 36% of the calcium in fortified orange juice and 42% of the calcium in fortified apple juice are absorbed. Even though more and more juice manufacturers are now fortifying their fruit juices and fruit drinks with calcium and vitamin D, please remember this general rule: More calcium is absorbed from less acidic juices than more acidic juices. So, even though Tropicana now fortifies its Ruby Red Grapefruit juice with more calcium than its orange juice, your body will absorb equivalent amounts of calcium from these two juices [27].

Age: In infants and very young children, the net absorption of dietary calcium can be as high as 60%. During the rest of childhood and adolescence it falls to about 30%. In young and middle-aged adults, only 15-20% of dietary calcium is absorbed. The remaining 80-85% is excreted in your urine, feces or sweat. In older adults, dietary calcium absorption decreases even more. Intestinal absorption of calcium can decline significantly with age (as much as 1-2% per year), particularly after the age of 70. It is believed these decreases in calcium absorption are largely because of reductions in the vitamin D-dependent active transport and "pumping" mechanisms in the duodenum. These decreases may also occur because of a lifetime of accumulated calcium-salt deposits within and between the cells lining the intestines, rendering these cells less able to passively absorb calcium. That is why it so critical that all adults, but especially the elderly, stagger their calcium intake throughout each day. Recent research indicates the dietary calcium absorbed from drinking a glass of low fat (1% or 2%, not 'Fat-Free' or skim milk) or consuming low fat (not fat-free) yogurt two hours before going to bed is more beneficial to the bone health of older adults than dietary calcium absorbed at dinner. When banana or strawberries, and a touch of sugar, are added to this late night snack, even more calcium goes into your bones and teeth, while little or none of their stored calcium is removed. Even though scientists do not currently understand why this 'bone-beneficial' effect occurs, they are pointing out this same 'snack' makes it easier for you to fall asleep, and improves the overall quality of your sleep [28].

Reproductive Status: Intestinal absorption of calcium increases to 55-60% during the first trimester of pregnancy, regardless of the mother's age. It remains elevated at this level until she gives birth, when it drops precipitously for several weeks, before rebounding again if she breast-feeds her baby. This increased absorption (and retention) represents an adaptive mechanism that increases the mother's bone density during the first and second trimesters of pregnancy. During the third trimester, the mother's increased 'bone stores' of calcium are significantly depleted to meet the tremendous calcium needs of her rapidly growing fetus [29].

This somewhat novel calcium absorption situation ends up being very beneficial to pregnant women over the age of 30, but harmful to pregnant teenagers. While the net effect of pregnancy

is to increase the maximum bone densities of women over 30, approximately one third of all pregnant teenagers develop osteoporosis of the lumbar spine by the time they give birth. Women who have three children also have significantly higher bone densities than women who never have a child. So, it appears becoming pregnant, giving birth and breast feeding, generally (provided one is **not** a teenaged mother) makes the bones of women stronger, decreasing the likelihood they will develop osteoporosis as they age [30].

[PLEASE NOTE: The answer to the question posed as the title of this essay is **YES, it is possible to be healthy and physically fit at 100.** But 'getting there' will be more difficult if you are lactose-intolerant or if you exhibited the signs of serious nutrient deficiencies as a youth or young adult. Specifically, all women need to be told many atypical experiences during pregnancy are early warning signs of serious nutrient deficiencies that predispose them to develop osteoporosis as they age. These early warning signs are not discussed in this essay, because they are covered in a separate essay on bone health and reproductive status.]

Vitamin D Status: Biologically-activate vitamin D (calcitriol) plays critical roles in calcium absorption in the intestines, retention in the kidneys and utilization throughout the human body. If a vitamin D deficiency exists, dietary calcium intake cannot be increased enough to satisfy the human body's calcium needs. [**NOTE**: This is also true whenever your calcium and vitamin D 'intakes' are adequate, but your vitamin K intakes are inadequate.] Recent studies indicate between 25-50% of all Americans are chronically vitamin D deficient, especially during the winter months [31].

Like calcium, vitamin D plays a key role in maintaining your bone health. Although it has long been known that severe vitamin D deficiency has serious consequences for bone health (rickets in children or osteomalacia in adults - see figure below), recent research suggests that less obvious states of vitamin D deficiency are not only fairly common, but also increase the risk of osteoporosis and other bone health problems like osteoarthritis, bone pain and bone cancer. Even fairly modest vitamin D deficiencies can cause muscle weakness and pain in both children and adults [32].

One normal child and two children with Rickets

Recent evidence indicates that chronic moderate to severe vitamin D deficiencies also play a role in developing a number of chronic diseases. Vitamin D deficiency is strongly implicated in the development of skin, breast, ovarian, colon and prostate cancer. It is also implicated in the development of several chronic pain disorders (fibromyalgia), muscle weakness, chronic fatigue syndrome, autoimmune diseases (multiple sclerosis, rheumatoid arthritis and Type I diabetes), high blood pressure, mental illnesses (depression, seasonal affective disorder and possibly schizophrenia), heart disease, psoriasis, periodontal disease, obesity, Type II diabetes, tuberculosis, Crohn's disease and celiac disease. New studies come out everyday showing an association between vitamin D deficiency and disease risk, leading some scientists to ask if there is any chronic disease not associated with a chronic vitamin D deficiency [33].

More and more foods are now being fortified with vitamin D because of the mounting evidence that rising rates of many chronic diseases may be associated with vitamin D deficiency. Because only one form of vitamin D, vitamin D3 (**cholecalciferol**), appears to be both safe and effective, it is **very** important to read food and vitamin supplement labels to make sure you are getting the right one. There are five forms of vitamin D, but humans can only convert two, D2 and D3, to the biologically-active form (calcitriol) the body actually uses. Vitamin D2 (usually listed as **calciferol** or **ergocalciferol** on labels) is available from food, fortified foods or vitamin supplements. Vitamin D3 is available from all these same sources, plus it is produced in your skin after ultraviolet-B (UVB) exposure from sunlight. For most humans, the vitamin D3 they make from sun exposure accounts for 75% of the biologically-active vitamin D in their bodies [34].

More vitamin D is not always better! In fact, 20 minutes of summer sun exposure is optimal. After 20 minutes of sun exposure, the skin stops producing vitamin D3. It then begins destroying the vitamin D3 it just made. In normal weight, lighter skin individuals, the body manufactures enough vitamin D3 to meet all its daily needs after only 10-15 minutes of unprotected summer sun exposure. Darker-skinned and tanned (even if the "tan" came out of a can or bottle) individuals only make half as much vitamin D3 in the same amount of time. But even tanned individuals increase their risk of getting sunburned after more than 20 minutes of unprotected sun exposure. This is important because persons with a history of bad sunburns anytime in their past make far less vitamin D3 in their skin than other people. This "bad sunburn" effect appears to be cumulative, and may explain some of the associations between decreased vitamin D-dependent calcium absorption in the intestines and vitamin D-dependent calcium retention in the kidneys with age [35].

Older adults: Even though most children and young or middle-aged adults get their optimal daily vitamin D3 benefits after **one** 10-15 minute "summer" exposure, this is **not enough** for anyone who is **over the age of 60** -or- **obese**. To maximize their benefits, older adults need 45-60 minutes of unprotected sun exposure. Since older adults are more likely to burn after having more than 20 minutes of unprotected sun exposure at any one time, they are strongly-advised to space their 10-15 minute "unprotected" sun exposures across the day. For example, older adults can meet their needs safely by taking a brief walk around 9 AM, another before or after lunch, and a third around 3 PM [36].

Obesity: In addition to needing more unprotected sun exposure than normal weight individuals, obese people of all ages need to lose weight and restrict their intakes of saturated fats in order to maximize their "sunlight" vitamin D3 status. First, there is some evidence that the skin of people who become obese never made as much vitamin D3 to begin with, when compared to people

who do not become obese. Second, much of the vitamin D3 that their skin does make gets trapped in the fats cells under their skin, and never makes it into their bloodstream so it can be converted to **calcitriol** (the active form of vitamin D) by their liver and kidneys. Third, it is believed that obese people may also have compromised vitamin D-dependent calcium absorption mechanisms in their duodenums, making it more critical for them to restrict their saturated fat intake [37].

Vitamin D-fortified foods: All milk and infant formulas are fortified with either vitamin D2 or vitamin D3 in the USA (but not in most of Europe or Asia), because of the known associations between vitamin D deficiency and rickets. But fortified milk and infant formulas rarely contain the amount of vitamin D stated on the label. More typically they are either under-fortified (milk) or over-fortified (infant formula). As recently as 2002, foods were typically fortified with vitamin D2. This is changing because we now know getting too much vitamin D2 from fortified foods or supplements can be harmful. You are advised to look at the label of the dairy products or formula you buy to make certain it is fortified with vitamin D3 [38].

In the case of fortified milk, one would have to consume at least 40 glasses ($2^{1/2}$ gallons) of milk each day to meet their daily vitamin D needs from milk alone. This is because milk is fortified with the absolute minimum amount of vitamin D required to prevent rickets (200 IU per day). It is **very** important to note that the milk used to make yogurt and cheese is rarely vitamin D-fortified, but this situation is slowly changing [39].

Natural food sources of vitamin D include: cod/ shark liver oil (highest sources, but can also be so high in vitamin A that they are not good sources), dark, fatty fish (salmon, mackerel, tuna, sardines and herring), organ meats (kidney, heart and liver), eggs (especially eggs high in omega-3 fatty acids), avocados and mushrooms. If you experience cravings for any of these foods, especially during the winter, you may have a vitamin D deficiency [40].

Vitamin D deficiency is never an issue for people living near the equator unless they are obese, never go outside or only go out after applying sunscreen. [FYI: If the SPF is 8 or higher, these products block out 90-100% of UVB light, preventing your skin from producing vitamin D3.] Vitamin D deficiency is a potential problem during the “winter months” for everyone else, and even more so, the further away from the equator they live. Many physicians now recommend having your vitamin D levels checked at least annually, typically in the late fall [41].

People are strongly advised to never take vitamin D-only supplements without first consulting their physician. Excessive vitamin D intake from supplements can lead to serious health problems. The ‘upper limit’ for vitamin D from non-dietary sources is now set at 2000 IU per day to prevent excess and toxicity from these supplements. Our government is currently reviewing recommendations from the medical community to (1) raise the recommended daily intakes from 200-600 IU (depending on age and skin color) to 600-1000 IU; and (2) double the ‘upper limit’ to 4000 IU for vitamin D3 [42].

Finally, before you ask your family doctor to test your circulating vitamin D level, be advised that many physicians still do not realize that only one of the two vitamin D blood tests is meaningful. More seriously, many diagnostic laboratories are, apparently, very sloppy when performing the correct test. If you have any interest in knowing more about the known associations between vitamin D deficiency and disease, or getting more information about the blood test you need to request, please contact me to request a copy of this information. A one

page description on the 'correct' vitamin D blood test, as well as a separate essay about vitamin D and health for people concerned about any of the chronic diseases listed earlier, are both available [43].

Vitamin K status: Vitamin K affects calcium absorption in the gut indirectly, by changing the shape of the proteins that are involved in vitamin D-dependent calcium transport so they can "package" calcium. It also does a similar thing in your kidneys to prevent calcium loss in your urine. That is why you require adequate levels of calcium, vitamin D **and** vitamin K at the same time, not just any one or two of them. But it is in your bones themselves where having adequate levels of all three is the most critical. Vitamin K regulates 'bone remodeling' in favor of bone formation, and against bone resorption. This means adequate vitamin K is required to prevent the age-related bone demineralization that can lead to osteoporosis. [FYI: It is also required to prevent heart diseases caused by poor dietary habits.] [44]

Vitamin K is a fat-soluble vitamin, but your body stores very little of it. Because vitamin K is so important to your survival, your body recycles it in the kidneys, by a vitamin D-dependent mechanism that requires calcium to work (yet another reason you require adequate levels of all three at the same time). There are two naturally occurring 'families' of vitamin K. Plants produce several forms known collectively as 'vitamin K1'. Bacteria make many other vitamin K forms, collectively called 'vitamin K2'. It was once believed that the bacteria in your gut made all the vitamin K you need. We now know this is not true. Your body **will** become vitamin K deficient without regular dietary intake [45].

Even when dietary intake is adequate, your body becomes vitamin K deficient when you are taking antibiotics, daily antacids (including Tums®), regular high doses of salicylates (like aspirin and Bufferin) or Orlistat (Xenical®: a new diet drug that prevents fat absorption in the gut). When this happens, abnormal calcium salts build up throughout the body, and your bones demineralize (lose calcium). Antibiotics produce vitamin K deficiency by killing off the intestinal bacteria that make vitamin K2. Antacids do it by decreasing the ability of these same bacteria to make vitamin K2. Salicylates and prescription blood-thinners like Warfarin (Coumadin) prevent the recycling of vitamin K, creating a functional vitamin K deficiency. [NOTE: People taking blood-thinners are cautioned against consuming very large or highly variable quantities of vitamin K in their diets. Doing so can be life-threatening.] The no-fat cooking oil olestra and diet drug Orlistat® decrease your vitamin K1 and K2 absorption from food and supplements [46].

The recommended daily intake for vitamin K was recently increased from 10-25 mcg per day to 65-80 mcg per day in recognition of how wide-spread vitamin K deficiency is in the USA. Recent studies indicate virtually every American between the ages of 18 and 44 is vitamin K deficient. Most older adults who suffer from heart disease, Type II diabetes, osteopenia or osteoporosis are also vitamin K deficient [47].

Because vitamin K deficiency is now considered a serious health problem, many American doctors have started recommending their older patients take a multiple vitamin supplement to prevent vitamin K deficiency. This is not necessarily good advice. Multivitamins generally contain only 10 to 25 mcg of vitamin K, but very high levels of vitamins A and E, which both interfere with your body's ability to absorb the vitamin K in these supplements. "Bone" supplements may contain 100 to 120 mcg of vitamin K (e.g. Viactiv® contains 40 mcg per chew). However, daily intakes between 200 and 250 mcg per day are required to prevent bone

demineralization and osteoporosis. So the best plan is to figure out how to get the bacteria in your gut to make more vitamin K2, and how to increase your daily intakes of vitamin K1 and K2 rich foods [48].

Nutritionists use the term "bioavailability" to describe which form of a nutrient (whether it is a mineral like calcium or a vitamin like vitamins D and K) your body is best able to utilize. For vitamin K, the K2 forms are most 'bioavailable'. This is because your body needs to convert vitamin K1 into vitamin K2 before it can use it. This means your best strategy to prevent or eliminate a vitamin K deficiency is to (1) help the "friendly" bacteria in your gut make as much K2 as they can; and (2) eat foods that are high in vitamin K2 [49].

The friendly bacteria in your duodenum (remember the diagram on page 4?) can make enough vitamin K2 to meet almost **half** of your daily vitamin K needs, if you let them. You just need to do the very same things you need to do to optimize your vitamin D-dependent calcium absorption in the duodenum. These critters thrive on the conditions eating 5-6 small, low in saturated fat, protein and sodium meals provide. If you eat a big or high fat meal that gives you heart burn, acid reflux or acid indigestion (GERD), they produce far less vitamin K2. If you then follow up this unhealthy meal with an antacid, they make even less. Without all that vitamin K2 your bacterial friends are so conveniently making, exactly where it is most needed to maximize your vitamin D-dependent calcium absorption, you are taking a big gamble with the health of your bones, heart and lungs [50].

There are several excellent food sources of vitamin K2. The very best source is a Japanese food called 'natto' (fermented soy beans). If you have ever smelled natto (see picture below), you probably won't be surprised to hear that ripe cheeses (e.g. Limberger, Blue, Gorgonzola, Brie, Camembert, Roquefort and etc.) also have very high levels of vitamin K2. Yogurts with 'active and live cultures' are also very good sources [51].

Natto: Stinky, sticky, gooey, but good for your bones, lungs and heart!

The best sources of vitamin K1 are dark green herbs (watercress, sage, oregano, mint, parsley etc.), vegetables (kale, swiss chard, broccoli, asparagus, spinach, Bibb or Boston lettuce, cabbage, green peppers, green beans, peas, green onions etc.) and fruits (kiwi, green grapes, green apples etc.). The simple rule of thumb is the darker green they are, the more vitamin K1 they contain. Cucumbers are very dark green, on the outside, and that is exactly where almost all the vitamin K1 is (in the skin/ peel) [52].

A little more than 1/2 cup of chopped broccoli or a large salad of mixed greens contains approximately 200 mcg of vitamin K1, but you will need to add enough saturated fat to get very much vitamin K1 out of them. So, if you stopped putting cheddar cheese sauce on your broccoli

to help your heart, you might reconsider at least adding back grated cheddar cheese. If you only use fat-free salad dressing these days, you probably goofed again unless you are adding ripe cheese crumbles instead of that Roquefort/ Blue Cheese salad dressing. [FYI: This is actually a good idea because it provides both vitamin K1-rich (the salad) and K2-rich (the ripe cheese) foods without the added fats and sodium in most commercial salad dressings.] [53]

Calcium excretion: Because urinary losses of calcium account for about half of the difference in calcium retention among individuals, calcium levels in urine are routinely used by research scientists to measure the effects of various nutrients (and non-nutrients) on calcium retention. Their basic assumption is: Any nutrients that increase your urinary losses of calcium are also increasing your risks of developing osteoporosis, kidney stones, arteriosclerosis, colorectal cancer, pregnancy-induced hypertension (preeclampsia/ toxemia), lead toxicity, high blood pressure and obesity. Conversely, any nutrients that act to decrease your urinary calcium loss, are also decreasing your risks of developing these medical problems [54].

Sodium: Excessive sodium intake is what really makes the **S**tandard **A**merican **D**iet worthy of its acronym, **SAD**. The average American consumes **over fives times** the amount of sodium their body needs, or even knows how to deal with. And no, you aren't adding all that excessive sodium to your diet (or even a significant amount of it) from your salt shaker [55].

On February 24, 2005, the Center for Science and the Public Interest (CSPI) sued the US Food and Drug Administration, for the second time, in an attempt to force it to begin regulating salt (sodium chloride) as a food additive. Several weeks earlier, CSPI published a 30+ paper titled: **Salt-The Forgotten Killer**. Their basic argument is everyone in the Federal government is either *blasé* about regulating the amount of sodium in the packaged, prepared, "fast" or restaurant foods we eat, or solidly 'in the pocket' of the 'Salt Institute' (i.e. the salt industry). Their secondary argument is our physicians typically prefer to prescribe us a pill to (hopefully) compensate for our excessive sodium intakes than to lecture us [56].

Even if you choose to ignore how harmful all that excessive sodium most Americans are putting into their bodies is to their hearts, please never forget this one fact: Each extra **teaspoon** of salt they consume in excess of their 2400 mg/ day RDA for sodium, produces an additional rate of bone loss of 2% per year in their bodies as they age. The minimum rule of thumb you should use is to never buy any commercially-prepared product where the sodium content per serving exceeds 10% of your RDA. If a particular item you really love is much higher (e.g. most canned soups), write the company and complain. You have a very loud voice when you do this. The company assumes at least 2,000 other consumers share your concern/ gripe [57].

Protein: As your dietary protein intake increases, your urinary excretion of calcium also increases. The typical American eats almost twice as much protein as their body needs each day. Because of this excess protein intake, they need to increase their daily calcium intake by at least 10-15%, simply to not risk demineralizing their bones. So, rather than eating that entire piece of meat or fish they just served you at your favorite restaurant, consider cutting it in half and taking the rest home for your lunch or dinner the next day [58].

Phosphorus: Next to calcium, phosphorus is the most abundant mineral in your body. Like calcium, it is required to build strong bones and teeth. In the USA, inadequate phosphorus intake is rare. Excessive intake is common (primarily from meats, soft drinks and food additives). Whenever you have more phosphorus than calcium in your bloodstream, your body removes

calcium from your bones. This can lead to osteopenia, and eventually osteoporosis. It can also lead to gum disease and tooth decay. Maintaining the appropriate balance between dietary calcium and phosphorus not only lowers your risk of developing osteoporosis, it also relieves many symptoms of osteoarthritis [59].

Potassium: Potassium is a mineral that helps your kidneys function normally. For most people, a healthy diet rich in fish, vegetables and fruits provides all of the potassium their body needs. One of the reasons the Federal government's new dietary guidelines recommend eating up to 8-9 servings of fruits and vegetables each day is because they are such good sources of potassium. Although a diet high in potassium is essential for the health of your heart, it is also important for preventing osteoporosis. This is because of the important role potassium plays in the recycling of calcium and vitamin K in your kidneys. However, the potassium status of your kidneys depends on sodium. Sodium excess depletes the body's stores of potassium, interfering with potassium's important roles in recycling essential nutrients. Bananas are very high in potassium, but they are also fairly high in sodium. Strawberries have about half as much potassium, but they are sodium-free. This is why a late night snack of milk and strawberries is so beneficial to your bones. Yogurt (if it has live and active cultures, and is fortified with vitamin D3 (i.e. Yoplait® yogurts) already has adequate potassium to maximize the benefits on your bone formation, and is low in sodium. This yogurt snack is also loaded with vitamin K2. So you are getting everything you need to optimize your calcium update in the gut and insure it makes it into your bones, and stays there [60].

Caffeine: Caffeine, in large amounts, increases calcium excretion, for a relatively short time. These effects are not seen when at least two tablespoons of whole milk are added to a cup of coffee, but they are an issue for people who consume large quantities of caffeine from other sources, especially soft drinks [61].

Magnesium: Like calcium, magnesium is important for the functioning of every cell in the body. It also makes important contributions to the health of teeth and bones. When calcium levels are adequate, magnesium interacts with calcium in ways that are beneficial to your health. When your dietary intake of calcium is inadequate, but you have excess magnesium levels, bone demineralization can occur. This situation is rare in the USA, except for those who regularly use certain types of antacids (i.e. Phillips Milk of Magnesia®) [62].

Conclusion:

The key to being healthy and fit at 100 includes (1) making certain your daily intakes of calcium, vitamin D3 and vitamin K are adequate; (2) avoiding prepared foods high in sodium; (3) taking short (10-15 minute) walks every day (the more the better) without sunscreens; (4) performing resistance/ weight bearing exercises 2-3 times a week; and (5) enjoying your vibrating chair or booties if you have them. You have to do all these things to reverse osteopenia or osteoporosis. Doing so benefits much more than your bones, it also benefits every organ and tissue in your body. But most importantly for the elderly, it holds considerable promise to help them control their blood pressure, Type II diabetes, prevent the development of chronic diseases and reduce or eliminate many of their discomforts from arthritis, decreasing their needs for many expensive prescriptions. Good luck on your way to living a long, active and vital life!