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The Calcium Paradox

In April of 2011, nutrition researchers shocked the medical community when they published—in the prestigious *British Medical Journal* no less—the results of yet another calcium and heart health study. According to the study, women who supplement with calcium to prevent osteoporosis are at a higher risk of atherosclerosis (formation of calcium plaques in the arteries), heart attack and stroke than those who don't.[1] The outcome was clear: the increased risk of death from heart disease associated with calcium supplements outweighed any benefit to bone health. Based on this research, for every bone fracture calcium supplementation prevents, it precipitates two potentially fatal cardiovascular disease events.

This was not the first analysis to report this staggering finding; it was the *third* trial to confirm the trend.[2] Confusion quickly set in among the millions of health-conscious consumers who heard the news—and among the health care providers who recommend calcium supplements. If we don't take calcium, aren't we doomed to crumbling, fractured bones from osteoporosis? If we do take calcium, are we doomed to suffer hardening of the arteries and death from cardiovascular disease? *Is calcium killing us?* The implications were so staggering and baffling that the studies were largely swept under the rug, so don't be surprised if you didn't hear about it at first.

Exactly how did the studies' authors arrive at their unsettling conclusion, and what does it really mean? According to this research, if 1,000 women take calcium supplements for five years, at the end of that period there will be three fewer bone fractures in that group compared to a similar group of women who didn't take calcium supplements. Three fewer fractures doesn't sound very impressive and other studies do report greater fracture-prevention power. However, even if you

take these results at face value and multiply those three saved fractures over the millions of women taking calcium supplements, it adds up to a meaningful benefit. Furthermore, it's the best nonprescription bet we've got. As long as there's no overwhelming drawback to popping calcium pills, then everyone should do it. And there's the rub.

The study goes on to say that in the same group of calcium takers over those same five years, there will be six more cardiovascular disease events (heart attack or stroke) than in the nonsupplement group. Six events in 1,000 women also might not sound like major cause for alarm, but it adds up too. More importantly, it's twice the number of fractures prevented, with potentially graver consequences. Curiously, the occurrence of heart attacks is not found to be dose-dependent. In other words, we do not see a greater number of heart attacks in women who take higher doses of calcium, a finding we'll explore later in this chapter. The researchers also note that the ill effect on heart health is not seen with dietary calcium from food. Given these results, the study authors make the staggering declaration that women should abandon calcium supplements.

But what about our bones? Critics of the calcium and heart health studies complain that the research generates more questions than answers. Sometimes groundbreaking research does that, but a more salient criticism is that the studies are raising questions that can't be answered by the research being done. Should we be taking calcium supplements or avoiding them like pleated pants? It turns out that the question "Are calcium supplements safe?" is the wrong one to ask. Studies looking only at calcium will never adequately answer that question—or they will inaccurately conclude that calcium is harmful. *The real question to ask is, "How can the body guide calcium safely into the bones where*

it helps us, and keep it away from soft tissues like arteries where it harms us?" The answer is a long misunderstood fat-soluble vitamin called K_2.

Why You Need to Read This Book, Whether or Not You Take Calcium Supplements

The calcium question—and its surprising answer—is not just for calcium supplement takers, and definitely not just for women. Even if you rely only on food for your calcium intake, heart disease, caused by a deadly accumulation of calcium in arteries, is the number one killer of both women and men in North America. Meanwhile, osteoporosis is a major cause of disability and death in the elderly of both sexes, and calcium and vitamin D supplementation haven't helped prevent it nearly as much as we'd like. This, in a nutshell, is the Calcium Paradox: a mysterious, concurrent calcium deficiency (in the skeleton) and calcium excess (in the arteries) that underlies two major health concerns of our time, osteoporosis and heart disease. Vitamin K_2 is the key to putting calcium back in its place to remedy this calcium conundrum. This book will tell you exactly how to do it.

In the face of evidence that calcium is dangerously collecting in blood vessels while our bones are starving for the mineral that is so close by, the advice to "just stop taking calcium supplements" misses the big picture. Calcium belongs in our bones just as gasoline (environmental objections aside) belongs in the tanks of our cars. You wouldn't go to the gas station and just spray fuel all over your vehicle; you use a nozzle to put the gas where it will do the most good. Vitamin K_2 funnels calcium into bones to strengthen mineral density and fight fractures while it prevents and even removes dangerous arterial calcification. Along the way it has beneficial effects for almost every major health concern of our

time, including diabetes, cancer, Alzheimer's disease, infertility, tooth decay and growing healthy children. Taking the paradox out of calcium is just the beginning of what vitamin K_2 can do for you.

There's more than a coincidental association between brittle bones and hardened arteries. Although multiple factors contribute to each disease, one common underlying mechanism unites both conditions: inappropriate calcium metabolism caused by vitamin K_2 deficiency. The very problem you are trying to stave off by taking calcium supplements predisposes you to having that calcium land in your arteries. In order to fully grasp what goes wrong in the Calcium Paradox—and how to put calcium back where it belongs—let's take a closer look at both osteoporosis and heart disease. Understanding the link between these conditions provides a framework for appreciating their connection to many other common ailments.

Osteoporosis: Calcium Deficiency

Osteoporosis is a loss of bone mineral density and thinning of bone tissue that causes bones to become more porous and prone to fracture. It is the most common bone disease, with one in five women over the age of 50 having the diagnosis, and many more having the disease that is yet to be diagnosed. Half of women over the age of 50 will experience a fracture due to diminished bone density. One in eight men over the age of 70 will develop osteoporosis, associated with a drop in testosterone that occurs around that age. There are no symptoms in the early stages of the disease; often the first sign of osteoporosis is a bone fracture due to little or no trauma.

Over time, osteoporosis can rob you of your posture—leading to a loss of height of as much as six inches—and result in a stooped stature

known as kyphosis (a humped back or "dowager's hump"). Osteoporosis-related fractures, especially of the hip and spine, are a leading cause of disability among seniors. For many people, recovery from hip fracture is a lengthy and painful process. For others, a hip fracture marks the beginning of a long, complicated decline in health from which there is no recovery. Up to one-third of hip fracture patients die within one year of their fracture. Up to 75 percent of those who were independent before their fracture neither walk independently nor achieve their previous level of independent living after breaking a hip.[3]

Osteoporosis drugs are at best a dubious solution to this widespread problem. One commonly prescribed medication, alendronate sodium, has been linked to necrosis (rotting) of the jawbone, even when taken for only short periods.[4] In other individuals, bisphosphonates, the most popular class of prescription drugs developed to treat osteoporosis, have the unfortunate side effect of *increasing* the risk of bone fracture.[5] Although debate continues about the long-term safety of these medications and whether periodic drug holidays will help protect patients from serious complications, it is certain that osteoporosis isn't caused by a deficiency of prescription drugs.

What does cause osteoporosis? Although we think of our bones as solid and unchanging, the skeleton is as dynamic as any other body tissue. The amount of bone mass in the skeleton increases until the age of 30, though 90 percent of your lifetime maximum bone density, called peak bone mass, is achieved by age 20. Between age 30 and menopause, women typically experience little change in total bone mass, but not because bone tissue is static. Old bone is continuously removed and replaced by new bone to maintain a strong, healthy frame. In the first few years after menopause, women often experience a rapid loss of

bone tissue due to a withdrawal of estrogen, with its bone-protective effects. The rate at which bone is lost eventually slows, but if too much bone mineral density is lost, osteoporosis results. Osteoporosis occurs when there is an imbalance between new bone formation and old bone resorption. The body may fail to form enough new bone, or too much old bone may be resorbed or both.

There are certainly genetic factors that contribute to weak, fragile bones, such as ethnicity and body type. Asians and Caucasians have it worse, and slim, small-framed women lose more bone density than their sturdier, more heavyset sisters. Exercise helps prevent osteoporosis, so women who are physically active have stronger bones. Of the factors we can control, other than being physically active, *osteoporosis is ultimately a product of how much peak bone mass you can accumulate by age 20 and how much of it you can keep after menopause.* Both of those factors are governed by vitamin K_2. The fact that osteoporosis becomes more common after menopause is not just inevitable bad luck for women. Declining estrogen levels negatively impact bone density in three distinct ways. Vitamin K_2 counteracts each of those pathological mechanisms. K_2 even affects estrogen metabolism itself.

Conventional wisdom has dictated that, since osteoporosis is characterized by a lack of calcium in the bones, adequate calcium intake is the most important remedy for the problem. Suggested calcium doses, above and beyond dietary intake, have climbed to over 1,500 milligrams daily, to only modest avail. Confusion persists and marketing hype abounds about the best, most absorbable forms of calcium that will really penetrate skeletal tissue, as if the ability to do so is a property of the calcium itself. This has led to much debate about the benefits of calcium carbonate versus calcium citrate, and created a market for

calcium supplements from ridiculously exotic sources like coral reefs and desert mineral deposits.

Why don't calcium supplements cure osteoporosis? Why does this disease seem to be so stubborn? The fact is, you could be consuming and absorbing plenty of calcium from food or supplements, it's just not getting to where you need it. Even worse, it might be landing in the last place you want it: gathering in your arteries, contributing to North America's leading killer, heart disease.

Atherosclerosis: Calcium Excess

The terms "cardiovascular disease" and "heart disease" encompass many pathological conditions. They can refer to a disease of heart valves or heart muscle, or other systemic disorders that affect the heart and/or blood vessels. Throughout this book, I use the term "heart disease" to mean only coronary heart disease (CHD), also known as coronary artery disease. CHD refers to a narrowing of the blood vessels that supply blood and oxygen to the heart. This narrowing is caused by atherosclerosis, a buildup of calcium-laden plaque that slowly clogs one or more of the coronary arteries, or any artery in the body.

Atherosclerotic heart disease is explored in Chapter 4 in detail. In short, as the coronary arteries narrow, blood flow to the heart can slow down or stop. This might cause chest pain (angina), shortness of breath and other symptoms, usually when you are active. More commonly, however, the gradual narrowing of arteries goes unnoticed for years until the sudden onset of a heart attack. In Canada, myocardial infarction—a heart attack—occurs once every seven minutes, and 30 percent of all deaths in both men and women are due to myocardial infarction. Even with cholesterol screening, electrocardiograms and

stress tests, the majority of heart disease cases go undetected until heart attack strikes, and 50 percent of first heart attacks are fatal.

Fighting heart disease has been a major public health concern for decades. The war against heart disease has largely dictated expert dietary advice over the last 50 years. Based on the principle that our diet—dietary saturated fat, in particular—predisposes us to heart disease, well-meaning diet dictocrats took to modifying our meals in specific ways to prevent heart disease. It wasn't particularly successful. We looked to cultures that have low rates of heart disease—French, Italian, Greek—and found them eating lots of saturated fat. We declared that a paradox and inferred that some secret ingredient, olive oil or red wine, is protecting them from the butter and egg yolks that must be killing us.

Although the lipid hypothesis, the notion that saturated fat and cholesterol cause heart disease, has been largely debunked in scientific literature,[6] it remains entrenched in popular nutrition dogma. Depending on your current awareness of the causes of heart disease, you will be pleasantly surprised or completely horrified by the list of foods high in heart-healthy K_2, discussed in Chapter 3. For now, let's just say that the French Paradox—the supposed contradiction between a rich, fatty diet and low heart disease rate—isn't such a paradox after all. And it probably isn't the red wine that's protecting those French (and Italian, Greek and Portuguese) arteries. Sure, there is some evidence to suggest that resveratrol, a compound in red grape skins, has heart health benefits, but it's nothing close to that of K_2. The shocking truth is that many of those rich, fatty "sin" foods are abundant in K_2, the only vitamin known to prevent and reverse atherosclerosis.

In 2004, the highly reputable *Journal of Nutrition* published the results of the Rotterdam Study. This population-based study, conducted

in the Netherlands, evaluated almost 8,000 men and women over age 55 on their health, use of medication, medical history, lifestyle and risk indicators for chronic disease and diet. The study revealed that a high intake of vitamin K_2 from dietary sources significantly reduced the incidence of arterial calcification and risk of death from cardiovascular heart disease by 50 percent as compared to people with low dietary vitamin K_2 intake. K_2 intake was also inversely related to severe arterial calcification and so-called all-cause mortality, or death from any cause.[7] According to this study, individuals with the highest dietary K_2 will live, on average, seven years longer than their K_2-deficient counterparts.

Why Vitamin D Won't Save Us from the Calcium Paradox

Vitamin D, another fat-soluble nutrient famous for bone health, has made major headlines in the last decade. Since vitamin D is beneficial for so many diseases, doesn't taking it help protect against the Calcium Paradox somehow? Unfortunately, it does not. Calcium supplementation increases the occurrence of heart attack and stroke with or without vitamin D, showing that the latter has no protective effect here. Even worse, it's possible that the soaring popularity of vitamin D might actually be compounding the problem. Under certain circumstances, vitamin D *increases* arterial calcification. Vitamin D specifically accelerates the accumulation of arterial calcification in vitamin K_2–deficient conditions.[8] With all the good news about vitamin D, how could this be?

The news about vitamin D hasn't been all good, just the widely publicized news. We know vitamin D is beneficial for bone health. When it comes to heart health, the research has been decidedly mixed. The results are so confusing and conflicting that researchers are only just now

making sense of it. Many studies indicate that vitamin D deficiency is associated with heart disease, and as vitamin D levels go up, arterial calcification decreases. Other studies show just the opposite—that higher blood levels of vitamin D are associated with more arterial plaque.[9] This double-edged sword can be partially explained by understanding what vitamin D does and doesn't do with calcium.

Vitamin D increases the absorption of calcium from the intestines, which is a good thing for bone health. Certainly, vitamin D and calcium supplementation together have been shown to increase bone density better than either one alone. However, once calcium is absorbed into the blood stream, vitamin D has no power over what happens to it, which is a potentially bad thing for heart health. Some calcium will find its way into your bones, but more of it might wind up in your arteries. Vitamin K_2 tips the balance in favor of bone *and* artery health by putting calcium in its place.

The fact that vitamin D governs calcium absorption only, then lets calcium run wild once we absorb it, explains only why excess vitamin D is bad for heart health. It doesn't account for the research showing that vitamin D deficiency is also associated with atherosclerosis, or why increasing vitamin D levels lower calcium plaque in some people. The answer to that lies in the fact that we need vitamin D to benefit from vitamin K_2 and vice versa. When vitamin D is lacking, vitamin K_2 can't do its job escorting calcium away from arteries and into bones. Chapter 7 fills in the details of this fascinating fat-soluble friendship.

This book does not dethrone vitamin D. In fact, it adds to the growing list of vitamin D benefits by placing vitamin D squarely in the "heart-healthy" category—as long as you take it with vitamin K_2. The sunshine vitamin truly is a wonder nutrient, if it has all the necessary allies needed to fulfill its potential. More vitamin D is better for heart health to a certain

point, after which more is worse. Exactly where that point is depends on vitamin K_2. Having plenty of K_2 enables us to profit from vitamin D like never before. If for years you have been following expert advice by dutifully gobbling up calcium and vitamin D, vitamin K_2 not only will allow you to finally reap all the benefits of those nutrients, it might just save your life.

How Vitamin K_2 Comes to the Rescue

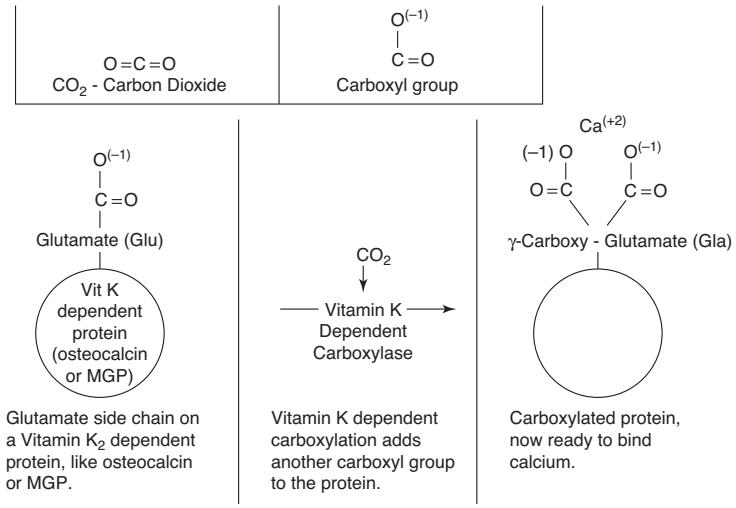
Vitamin K_2 works by activating a number of special proteins that move calcium around the body. Specifically, K_2 activates a protein called osteocalcin, which attracts calcium into bones and teeth, where calcium is needed. K_2 activates another protein called matrix gla protein (MGP), which sweeps calcium out of soft tissues like arteries and veins, where the mineral is unwanted and harmful. When K_2 is lacking, the proteins that depend on K_2 remain inactive. The Calcium Paradox then gradually rears its ugly head with an insidious decline in bone mineral density and an even more treacherous hardening of the arteries. When K_2 is plentiful, bones remain strong and arteries remain clear.

Throughout this book I often refer to the benefits of vitamin K_2—or the problems associated with a lack of it—by referring to the actions of the K_2-dependent proteins, especially osteocalcin and MGP. When these proteins are switched on by vitamin K_2, they actively usher calcium to and from appropriate areas of your body. When K_2 levels are inadequate, those proteins are useless and calcium wanders aimlessly, eventually taking the path of least resistance, embedding in soft tissues rather than trying to force its way into hard bone. Although the discussion may seem technical, taking a few minutes here to grasp the nature of these K_2-dependent proteins will allow you to really appreciate the amazing power and profound health benefits of vitamin K_2 that you'll learn about later in the book.

The term "protein" usually conjures up images of beef, chicken and eggs. These foods are high in essential dietary protein, but the word "protein" in the term "K_2-dependent protein" refers to something slightly different. Biological proteins are microscopic components made up of amino acids. Most biochemical reactions in any living organism occur due to the action of some protein, usually an enzyme. An enzyme is a catalyst, a protein that facilitates biological reactions.

Biological proteins need helper molecules, called cofactors, in order to work. Vitamins and minerals are cofactors. Indeed, the purpose of most vitamins and minerals in our diet is to act as cofactors for our body's proteins. Vitamin K_2 is the cofactor for an enzyme called vitamin K–dependent carboxylase. This enzyme, once and only once it is activated by vitamin K_2, alters the structure of osteocalcin and MGP to allow those proteins to bind calcium (see the sidebar "Gamma-carboxylation" for the keener-level details). Once these proteins have the ability to bind calcium, they can work wonders.

Gamma-carboxylation



The K family of vitamins activates enzymes that modify certain proteins to allow them to bind calcium. Vitamin K_1–dependent proteins are involved in blood clotting. Vitamin K_2–dependent proteins move calcium into bones and out of soft tissues like arteries, veins and skin. The process by which K_1 and K_2 activates proteins is called gamma-carboxylation. When vitamin K_2 is deficient, we say the K_2-dependent proteins are "under-carboxylated." This term is synonymous with vitamin K_2 deficiency.

Osteocalcin (also known as bone gla protein or BGP) is a biological protein found in bones and teeth. It is the most abundant protein in bone after the collagen that forms the matrix that holds calcium. Together, vitamins A and D cause special bone-building cells (osteoblasts) in our skeleton to secrete osteocalcin and use the protein to draw calcium into bone tissues. Osteocalcin isn't ready for work as soon as it is made, though. It won't work at all until its structure assumes a shape that allows it to bind calcium—and that doesn't happen by accident. It takes vitamin K_2 to activate (carboxylate) osteocalcin so it can bind the precious mineral we need to build our bones and teeth. Inactive (under-carboxylated) osteocalcin is powerless; it won't bind calcium and it won't build bone tissue. In fact, measuring your level of inactive osteocalcin is a handy way to assess K_2 deficiency; if K_2 is lacking, more useless osteocalcin will be hanging around. Vitamin K_2 deficiency testing is discussed in Chapter 6.

In addition to building bone density, osteocalcin, produced by our bones and teeth, plays some unexpected roles in health. For example, new research shows that osteocalcin acts as a hormone that causes the pancreas to secrete more insulin and increases sensitivity to insulin at

the cellular level.[10] Insensitivity to insulin (also called insulin resistance) is at the heart of the epidemic of obesity and type 2 diabetes that now plagues the Western world. This new understanding of osteocalcin confirms that our skeleton is not just inert scaffolding. It is an endocrine gland that plays a role in the prevention of diabetes. More to the point, *vitamin K_2, essential for osteocalcin to function, is likely a critical nutrient in preventing and treating type 2 diabetes.* In addition to osteoporosis and coronary heart disease, a decline in dietary K_2 has no doubt contributed significantly to the obesity and diabetes crisis that is upon us.

Another newly identified and even more astonishing role for osteocalcin is in male fertility. Men's bones, via secretion of osteocalcin, actually help regulate testosterone production.[11] This impacts sperm production and survival in the testes. No doubt this is the mechanism that underlies the traditional wisdom of many cultures that men preparing to become parents consume plenty of K_2-rich foods. Indeed, K_2 plays so many roles in male and female fertility, perinatal wellness and growing, healthy children that I devote much of Chapter 5 to that information.

Just as K_2-activated osteocalcin directs calcium into bones and teeth, where it is helpful, osteocalcin's counterpart, matrix gla protein (MGP), escorts calcium out of the areas where it is harmful, like arteries and veins. MGP resides in numerous body tissues, including bones and that of the heart, kidneys and lungs. As with osteocalcin, vitamin D stimulates MGP production. Mice that lack MGP altogether die within two months of birth as a result of massive arterial calcification that leads to blood vessel rupture.[12] In animals and humans, when MGP is present but remains mostly or even partially inactive due to lack of K_2, the same calcification process occurs, just milder and more slowly.

Vitamin K_2–activated MGP is the strongest inhibitor of tissue calcification presently known. Its pivotal importance for cardiovascular health is demonstrated by the fact that there seems to be no effective alternative mechanism for preventing calcification in blood vessels.[13] In other words, when vitamin K_2 is deficient, the calcium plaque buildup of atherosclerosis is unavoidable—and this is where things get spooky.

When I mentioned earlier that unsupervised calcium eventually becomes embedded in arterial tissue, it may have sounded like a passive process. That's a popular misconception. If inappropriate calcification happened by chance, we'd expect the calcium and heart health studies to show more cardiovascular disease events in people who take higher doses of calcium, but they don't.[14] Furthermore, if calcification were an indiscriminate process, we'd also probably see randomly calcified bits here and there throughout the body, but we don't. The arteries aren't the only tissues that can develop ectopic (out of place) calcification, but they are usually the first and most sensitive areas.

For a long time, the prevailing notion of the arterial calcification process was that it was a passive affair associated with advanced atherosclerosis. In other words, when fatty material had clogged arteries for long enough, it would eventually harden, due to calcium deposits, because there was no particular mechanism to prevent calcium from building up. Now we know that isn't the case. Calcium is actually present in a fairly consistent ratio—occupying about 20 percent of the volume of an arterial plaque—from the very early stages of the plaque formation. That is why greater calcium intake doesn't translate into more heart disease, as shown by the calcium and heart health studies that sparked this discussion.

Calcium doesn't drift into arteries by fluke. Minerals deposit into atherosclerotic plaques by an active process that mirrors bone formation.

Artery wall calcification due to atherosclerosis frequently contains fully formed bone tissue, including marrow.[15] Osteoblast- and osteoclast-like cells within the artery go haywire and actually form tissue that, under a microscope, is indistinguishable from bone. Arterial calcification is really a process of ossification—bone building.

In a sense, this weirdly inappropriate bone-building phenomenon has protected us from even more serious effects of widespread calcium supplementation. Rather than having all the unusable calcium clogging our arteries, only a portion of it winds up there. That's good news, at least, but the fact remains that we need calcium to build our bones, and we can't afford to sacrifice our heart health to get it. What causes dormant, bone-building-type cells in our blood vessels to malfunction and create bone tissue where it should not be? Vitamin K_2 deficiency. By activating MGP, vitamin K_2 ensures calcium contributes to bone tissue buildup only where it should and prevents bone from being laid down where it shouldn't be.

K_2-activated MGP doesn't just prevent atherosclerosis, it reverses life-threatening arterial plaque. Yes, you read that right. It is actually possible to lessen plaque burden by stimulating more of your MGP to actively sweep calcium away. Animal studies show a 37 percent decrease in arterial calcium content after only six weeks on a vitamin K_2–rich diet. This benefit is mediated entirely by K_2-activated MGP.[16] MGP is now being used as a biochemical marker for arterial calcification. Blood tests that measure your level of active versus inactive MGP can accurately predict how much calcium plaque you have. Vitamin K_2 supplementation increases active MGP levels in humans in a dose-dependent manner: more K_2 means more K_2-activated MGP.[17] This, in turn, means less arterial calcification.

Not worried about heart disease because your cholesterol isn't high? Keep in mind that heart disease is not called a silent killer for nothing. Ninety percent of cases go undetected until heart attack strikes.[18] Whether your cholesterol is high or low, what really matters is whether calcium plaque is building up in your arteries, leading to a potentially fatal blockage. Since heart disease is the number one cause of death in North America—and just focusing on cholesterol will lead you astray in cardiovascular disease prevention—it's worth learning how to get K_2 back into your diet.

Unlike osteocalcin, which, with a few notable exceptions, is mostly confined to bone tissue, MGP pops up throughout the body. It is found in bones, blood vessels, the heart, lungs, kidneys and cartilage. Uncarboxylated, K_2-deficient MGP is associated with disease in each of those areas. Curiously, many types of malignant tumors also produce MGP for reasons unknown. Probably not coincidentally, K_2 deficiency fosters cancer growth. Scientists continue to explore the role of MGP and vitamin K_2 in multiple health conditions, and amazing benefits are still emerging.

The Calcium Cycle of Life

There is a fascinating interplay between fat-soluble vitamins, calcium metabolism and the seasons, which conveys the interconnectedness of osteoporosis and atherosclerosis. Both arterial calcifications and bone density vary according to an annual cycle. Arterial plaque builds up in the wintertime and diminishes slightly in the summer, a phenomenon explored further in Chapter 4. Bones do the opposite. Bone mineral density loss occurs almost exclusively during the winter, with virtually no loss in the summer.[19] Unfortunately, the lost bone mineral content isn't usually regained in summer, but bone density at least remains constant

at that time. On an annual basis, then, calcium is lost from the skeleton at the same time it is accumulating in arteries. Supplementing with calcium and vitamin D prevents winter bone loss, but popping calcium pills during prime plaque-building season is risky. Ah, the Calcium Paradox thumbs its nose at us once again.

The complete answer to this cyclical calcium riddle will unfold throughout the book. It has to do with humans' delicate interconnectedness to the sun and the earth. For the moment, suffice it to say that vitamin K_2 cooperates with other fat-soluble nutrients so that we may benefit from calcium without risking harmful side effects. There has always been an annual variation in osteoporosis and atherosclerosis—this is the ebb and flow of life. Understanding this pattern and what causes it provides a framework for understanding what a healthy diet really is and when vitamin supplements are needed. Supplementation on top of excellent nutrition may help us cheat death just a little bit, or at the very least buck the seasonal trend.

We All Need More: Vitamin K_2 Deficiency Is Widespread

Now that you know how vitamin K_2 works in the body, what's to say you don't already have enough of it? If you know you have either osteoporosis or heart disease (or both), K_2 deficiency is a given—but keep in mind that most people are unaware they have those conditions until disaster strikes. If you are menopausal or have a history of cancer, infertility, varicose veins or diabetes, the likelihood of K_2 deficiency is very high, since those conditions are all associated with an increased requirement for or deficiency of the nutrient. For other hints that you might be lacking K_2, scan the list of K_2-deficiency conditions below.

Conditions associated with vitamin K_2 deficiency:

- osteoporosis
- atherosclerosis
- increased risk of cancer (including breast, prostate, liver)
- diabetes
- varicose veins
- wrinkles
- dental cavities
- Crohn's disease
- kidney disease
- narrow, crowded dental arch
- adolescence

Even without any of these health concerns, another very compelling factor points to the strong probability that you are K_2 deficient: according to recent research, most people are.[20] A 2007 study revealed that the majority of "apparently healthy" individuals have substantial levels of under-carboxylated osteocalcin and matrix gla protein (MGP), caused by vitamin K_2 deficiency.[21] In other words, most people do not have adequate vitamin K_2 levels to fully activate the proteins needed for optimal bone and heart health. If you can be K_2 deficient and apparently healthy, then what's the big deal? Based on the most current understanding of how and why we grow old, the triage theory of aging, undetected vitamin K_2 deficiency now will take its toll later in life. Poor vitamin K_2 status must be regarded as a serious risk factor for increased postmenopausal bone loss, artery calcification, diabetes, end-stage kidney disease and aging itself.

K_2 has a better-known sibling called K_1, whom we'll meet in Chapter 2. The main role of K_1 is in blood coagulation, not calcium metabolism.

In healthy people, 100 percent of K_1-dependent proteins are activated by vitamin K_1. In contrast, a varying percentage of osteocalcin and MGP is left inactivated by K_2 in the same people. While most everyone gets the vitamin K_1 they need for proper blood clotting, researchers rarely find an individual with enough vitamin K_2 to meet their calcium-metabolism needs. As important as coagulation is, vitamin K_1 has no effect on heart disease risk, judging by the Rotterdam Study, and little effect on bone strength. Almost everyone is lacking vitamin K_2; we differ only in the degree of deficiency. It wasn't always this way. Exactly how we got into this sorry state—and how to get out of it—is explained in Chapter 3.

Critics of the calcium/heart health studies point out, and rightly so, that saying there is an increase in heart attacks and strokes in women who take calcium is not the same as saying calcium supplements cause heart attacks and strokes. That is true, but it's kind of like arguing that bullets aren't harmful. Calcium supplements are the ammunition in the weapon of vitamin K_2 deficiency. Should you discontinue calcium supplementation altogether to avoid heart disease? Not necessarily. With sufficient K_2, however, you might benefit enough from the calcium naturally present in a healthy diet to not need calcium supplements.

For those with osteoporosis, calcium might still be needed. What about vitamin D? As I explain in Chapter 7, taking vitamin D increases the body's need for K_2. By jumping on the vitamin D megadose bandwagon, you are compounding the potential danger of calcium supplementation if you are not also taking K_2. Conversely, vitamin D boosts the requirements and potential benefits of K_2. You can profit from vitamin D without increasing your risk of inappropriate calcification by having a balanced intake of all the fat-soluble vitamins, including K_2.

The discovery of vitamin K_2 is the final piece in the nutritional puzzle of many widespread diseases. How is it possible that we overlooked this incredibly important vitamin until now? It was, in part, a case of mistaken identity. The next chapter tells the story of how K_2's more popular sibling distracted our attention for decades, and how fascinating research about K_2 was hidden in plain sight for over seven decades. Read on to learn the answer to a 70-year-old mystery, and how you can make sense of conflicting information to ensure your diet supplies the kind of vitamin K that counts.