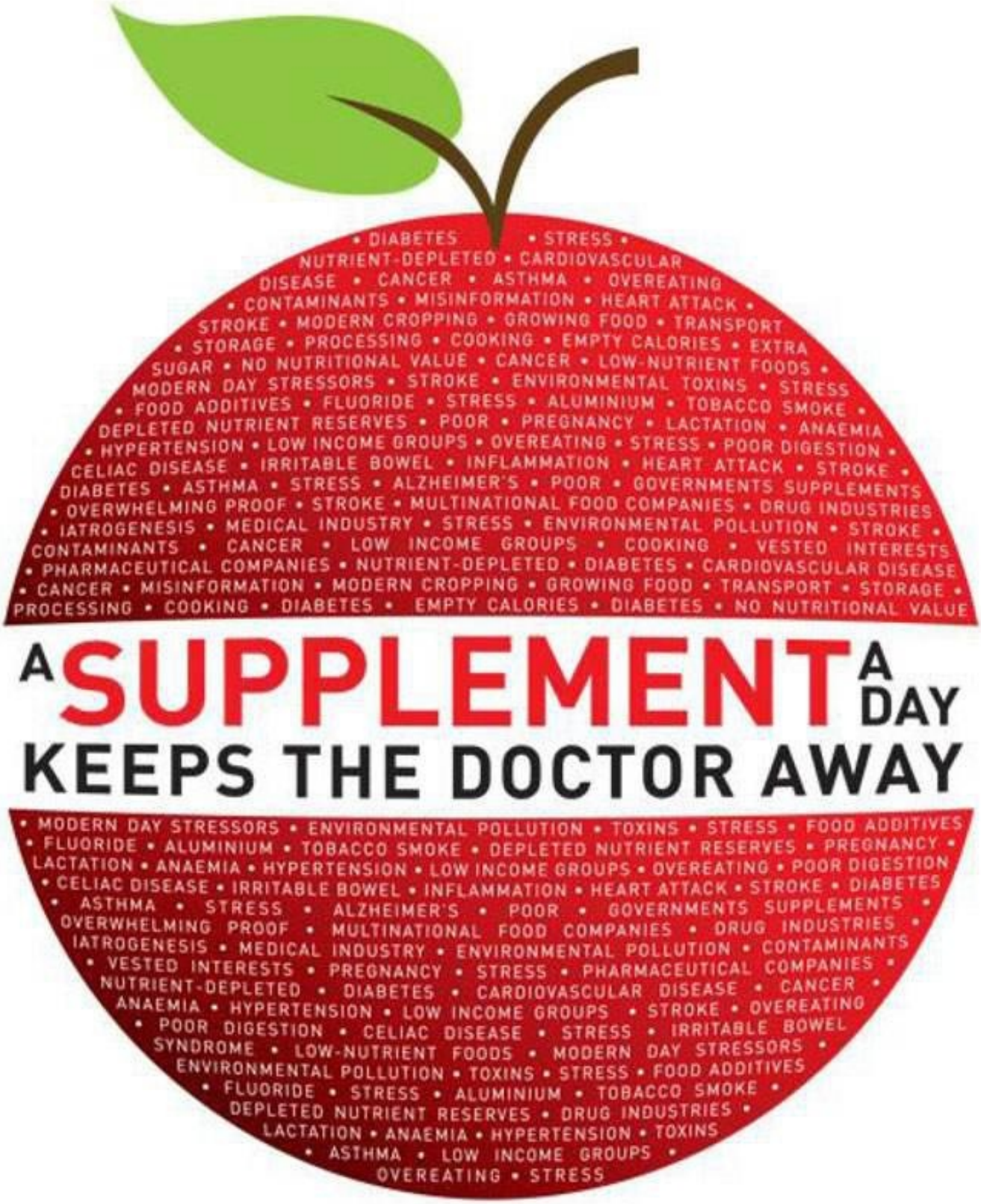

A SUPPLEMENT A DAY KEEPS THE DOCTOR AWAY

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The Science of Why We Need to Supplement Our Diet

PETER DINGLE PhD

A Supplement a Day Keeps The Doctor Away:
The Science of Why We Need to Supplement Our Diet
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Pan metron ariston. All good things in moderation.

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WHY WE NEED TO SUPPLEMENT

In the beginning there were healthy, whole foods and healthy lifestyles; people took responsibility for their own health. Now most of the world is dying from food-related illness. Half the world is dying from not enough food and the other half from too much nutrient-depleted, calorie-dense food. Times have changed and so has the way we need to look at food, nutrition and our health. Chronic illnesses such as diabetes, cardiovascular disease and cancer are now the biggest killers in developed countries. The current medical model that focuses on treating, rather than preventing, illness is simply not working. As individuals we need to take responsibility for improving our health.

For years, a so-called debate has raged over the relative importance of dietary supplements as a means of maintaining good health and safeguarding against disease. The debate has, unfortunately, not relied on good science but rather has been fuelled by a very small number of quasi-scientific studies that have been fraught with controversy. Even the “unbiased” research findings have often been misrepresented by the medical industry and by popular media in attempts to create the next controversy. Such an excess of misinformation has led to a strongly divided public and professional opinion on the place of supplements in our diet.

Most people should be taking supplements because eating a balanced diet all of the time and absorbing the required nutrients all of the time are almost impossible for people throughout the world. The argument for supplementation is easily summed up into several main areas, which I cover in depth throughout this book. The first is that it is no longer possible to get all the nutrients that should be in our food. Through modern cropping, growing and harvesting techniques, transport, storage and marketing, not to mention processing and cooking, it is possible to lose 100% of the nutrient value of the food and, in its place, add toxins. This means that if it is not in the food we eat, we have to get it from supplementation. The modern day processed “white foods” such as sugar, bread, white rice and processed breakfast foods are full of empty calories and, often, extra sugar and are low in nutritional value. Unfortunately these foods now make up a large portion of many people’s food intake. Meanwhile, most people rarely consume their full share of fruit, vegetables, nuts and beans and other nutritious foods—or when they do consume vegetables it is usually in the form of over-processed potatoes without the nutrient-dense peel.

In addition to low-nutrient foods that make up our diets, we are now inundated with many new stressors, including environmental toxins and modern day stress that increase the body’s need for nutrients. From food additives and contaminants to fluoride and aluminium added to water, increasing environmental toxins in our homes, and the effects of pollutants like environmental tobacco smoke decrease our nutrient reserves and place increased stress and nutritional demands on our bodies.

During periods of increased physiological and metabolic demands, for example pregnancy and lactation, pregnant women require more energy and nutrients to meet the needs of the developing foetus. During this time, inadequate stores or intake of vitamins or minerals, referred to collectively as micronutrients, can have adverse effects on the mother, such as anaemia, hypertension, complications or even death during labour. Furthermore, the foetus can be affected, resulting in stillbirth, pre-term delivery, intrauterine growth retardation, congenital malformations, reduced immune-competence and abnormal organ development.
There are many subgroups within our population who are likely to have a significantly lower than average nutritional status. This may be a low-income group, the aged or maybe a group with a particular disease or disability. For example there are a large number of growing disease conditions that reduce our ability to digest and absorb nutrients even when they are available in food. These range from the increasing stress that affects everyone to overeating, poor digestion, celiac disease, irritable bowel and other inflammation diseases of the gut. An important fact to remember is that the nutrients have to get to the cells where the real work is done. If they don't contribute to cellular nutrition, they are worthless, no matter what you eat.

The science is overwhelming—with the publication of thousands of articles in all levels of scientific journals—on the benefits of supplementing, not only for the general population but also for specific illnesses and disease conditions. Unfortunately these do not seem to get media attention despite the fact that they may show dramatic reductions in the incidence and severity of diseases such as heart attack, stroke, cancer, diabetes, asthma, Alzheimer's and many more. If these sound like wild claims, keep reading, as you will find evidence for this as you read this book.

In fact, most people do supplement, especially those who know the most. Our own research shows us that people who supplement are usually the people who have higher levels of education, enjoy a healthier diet and lifestyle and are more interested in health; these are people who are taking responsibility for their own health. Interestingly, many health professionals—despite what they may tell you when conforming to medical industry standards—take supplements. The increasing use of dietary supplements in general is one example of better health through preventative measures, which is a result of consumers wishing to take charge of their own health.

Far too much credit is given to the Recommended Daily Intakes (RDIs) of nutrients, the information on the side of your breakfast food box, as the guide to healthy nutrition. These guides are based on preventing acute nutrient shortages and helping basic growth, not preventing and treating modern day epidemics. There has been a big shift in thinking from the concept of "adequate nutrition," being all that is required, to "optimal nutrition" to help us flourish and be free of disease. We have chronic illness related to diet and nutrition in epidemic proportions and the so-called professionals say it is o.k. because some people meet the RDI levels. This is insanity! Our early nutrition models were great for preventing scurvy and pellagra but not for the chronic illnesses that afflict so many now.

All too often even though the evidence is there it takes decades or even longer to get it through the wall of vested interests. Perhaps we can learn from history. In 1601, Captain James Lancaster gave lemon juice to his ship's crew, one of four ships in his fleet. The men on the three ships without lemon juice suffered terribly from scurvy and many of them died. Even though the benefits of lemon juice were well established on this and many other ships, it took nearly two centuries—during which time nearly one million men died from scurvy—before the British government adopted and implemented this cure. More recently, it took two Australian doctors almost a decade to get their evidence accepted that a simple bacteria, Helicobacter pylori, which can be easily treated with a short-term doses of antibiotics, is a major culprit in stomach inflammation and ulcers, *not* too much acid and stress. This finding threatened the very lucrative antacid treatment and the egos of many medical professionals who had been recommending drugs for the past 30 years to treat the symptoms of gastritis and peptic ulcer disease. The doctors were recognized and later awarded a Nobel Prize in 2005 for their work after they infected themselves with the bacteria to develop ulcers then fixed it with simple antibiotics. Pretty harsh when you have to do that, but the medical profession would still treat gastritis and ulcers with ineffective drugs if the researchers had not gone to such drastic extremes.

The government supplements, so why can't we do the same? Despite their rhetoric, governments have been pro-supplementation through their fortification of breads and breakfast foods and salt. Governments all around the world have requirements for nutritional supplements to be added to foods —from vitamins B1, B2, B3 and B6 (pyridoxine) and iron in breads and cereals to iodine in salt. However, government's fortification efforts have been a bit myopic, ignoring the fact that nutrients work together. The B vitamin group are all water-soluble and often work together in the same metabolic pathways. So just supplementing with folate or B6 may mask, or even lead to, deficiencies in other B vitamins such as B12. In nature, iron is often associated with zinc; the food industry ignores this fact when supplementing breakfast foods with iron. And little do most consumers realise when they take zinc in breakfast cereal, the high phytate content of cereals binds it up, stopping its absorption into the body. The limits of government supplementation are further highlighted by the fact that the iron put in processed foods is not readily absorbable.

The proof however is in the pudding. I have seen so many people, literally in the hundreds, who have told me how they have benefited personally from supplementing. I have seen people's lives changed dramatically as a result of supplementation. I have seen people with advanced cases of multiple sclerosis, confined to a wheelchair, get up and walk. I have seen people riddled with arthritis and convinced that there is nothing that medicine can do have free and flexible movement without any pain. Cancer patients who were once practically given up for dead are still alive 20 or 30 years later and their quality of life has improved dramatically as a result of supplementing their diets. Most commonly though, I see people who have a new lease on life, they feel better and have more energy and libido.

Professionals from the old school of nutrition argue that you can get all the nutrients

you need from a balanced diet. Recent research in the areas of environmental, nutritional and biochemical science suggest otherwise. Even more complex is the concept of a balanced diet. The average American, Brit or Australian eats one or two vegetables serves per day, a couple of pieces of fruit and a lot of overprocessed and nutrient-depleted foods. The nutrient-depleted foods require other nutrients in order to be digested, absorbed, utilised and eliminated from the body. This may actually rob the body of nutrients rather than providing them. The problem is further exacerbated by the literature and the research fed to the public, as it comes through advertising by multinational food companies. Many of the professional and public health associations that provide so-called independent advice also derive their income from the food and drug industries. Are you sure you can trust them?

Why is it that stores about vitamins and minerals being bad for you receive a huge amount of press coverage? If you are concerned about risk, then perhaps you should look at the thousands of Australians and tens of thousands in the U.S. who die every year from the prescribed use of pharmaceuticals and the hundreds of thousands of people who report adverse effects to these legal drugs. By contrast, I could not find any record in Australia or the U.S. of a person dying from vitamin or mineral supplementation and around the world no more than half a dozen people have died when they took extremely high doses of supplements. However, I could find literally thousands of peerreviewed, scientific, published journal articles, including results from double-blind placebocontrolled studies that show clear and substantial benefits from supplementation for many illnesses. By contrast, prescribed medication is the third biggest killer is the U.S. after cancer and cardiovascular disease. Some estimate iatrogenesis, death caused by the medical system’s treatment or advice, as the single biggest killer. So why aren’t the medical profession speaking out against this? Why isn’t this front-page news? How many people have you heard of dying from taking vitamin or mineral supplements? We regularly hear of famous people dying from side effects or overdoses of legal drugs. Perhaps this is a reflection of a society too dependent on drugs, one that too frequently treats health complaints with drugs rather than investigating nutritional solutions. Despite more money being spent on the medical system each year, we have more chronic illness than ever before. In fact, as the U.S. spends more money each year on its drug-oriented medical system, it drops down in all wellness stakes including longevity. Get the idea? We are on the wrong track. The U.S. has the highest infant drug treatment regime in the developed world and also has the highest level of infant mortality while the countries with the lowest drug intervention have the lowest infant mortality.

Many specialist surgeons and doctors will be critical of supplementation, but how can they claim to know best when they have not studied the topic? Many of my third-year university students have studied more on this topic in one unit than most specialists do in their entire careers. It is an interesting (and sad) state of affairs when many of the lay public know more about nutritional health than their GPs and specialists. The scientific literature shows that nutritional training in medical schools is at a bare minimum. Doctors should not be highly critical of supplements without spending time and energy to investigate supplementation and nutrition and not just accepting what

their unions tell them to. It is time we create a generation of doctors who think for themselves.

Rather than trying to blame supplementation, the medical industry should be learning more about nutrition and giving people correct guidance. There is some progress: already more than 10% of GPs have taken nutritional medicine courses and now use supplementation as a major mode of treatment. Most of the others remain ignorant and arrogant and are not willing to open their minds and challenge their conditioning. These are the same doctors who overprescribe medication after a 10-minute interview. And, despite what they tell the public, many in the medical profession already take supplements themselves. My concern though, is for the GPs and specialists who recommend toxic pharmaceuticals without first investigating the role of diet, nutritional supplements and lifestyle changes, because once the lawyers pick up on this these doctors will be sued for not recommending safer and more effective treatments. It is a moral and ethical requirement for medical doctors to investigate safer, non-invasive treatments before they dish out drugs with serious side effects.

Doctors do need to be sceptical about information on supplements, but they also need to exercise that same scepticism about the drugs that are foisted on them. They must develop the ability to go beyond the PR machine and look at the science behind these products. A quick search on the Internet will show hundreds of court cases pending against the big drug companies for their deception and deceit— including some cases in which the drug companies' deception even led to tens or hundreds of thousands of deaths, or illegal experimentation in developing countries. And the doctors still trust pharmaceutical companies and their studies?

The allopathic doctors' disease-oriented system is based on fear and putting the fear of God in patients if they don't take their drugs. Many times I have met with patients in tears and distressed as a result of being threatened by their doctors and told that they would most likely die if they did not take their medication. The medication in most cases would not provide any more than a one- or twopercent benefit and certainly would be nowhere near as effective as minor changes in diet, lifestyle and supplementation. I spent two years along with one of my students reading and researching scientific articles on statin drugs used to lower cholesterol and found they have deadly and severe side effects and don't actually save lives. They lower cholesterol but don't save a single life. We prescribe statin drugs to some half a million Australians and tens of millions Americans every year at a cost of billions and billions of dollars. Now that is expensive urine. It would be better to turn to the chapter on cardiovascular disease in this book and, with simple lifestyle and dietary changes including supplementing, to really reduce your risk of heart attack and stroke.

Everyone wants good health but we have an epidemic of chronic illness and our medical system does not know how to deal with it. Practitioners should focus on protection, prevention and sustainable health but that does not fit their medical model that reinforces drug treatment of symptoms. Less than one percent of the health budget is spent on prevention although all the research shows money spent on prevention has

many times more benefits than trying to treat people once they have become ill. Millions of Australians now supplement because they see it as a crucial role in prevention, even if they do not get reimbursed for the cost of supplements by their health funds. Similarly, millions of Australians visit naturopaths and other natural health practitioners who use a lot of nutritional supplementation at a cost of one hundred or more dollars without any reimbursement from Medicare. Around 80% of Australians see a natural therapist for their health each year. Why are so many people turning away from the modern day allopathic medical model, and instead turning to natural therapies, supplements and nutritional healing?

There is no doubting the benefits of the best thing we can do for our health: eat well. Eating more fruit, vegetables, beans, nuts, whole grains and fish is spelt out in my other books including *My Dog Eats Better than Your Kids* and *The Six Week Healthy Eating Planner*. However, even this will not guarantee all the nutrients your body requires, because of the nutrient losses in our food before it even reaches us.

This book describes all of this in a lot more detail and hundreds of references. It describes the logic and science behind the loss of nutrients in our food and how particular diets, illnesses or other conditions can impact the absorption of nutrients. It also explores the impact that environmental pollution, contaminants and personal factors such as stress have on depleting our nutritional status. It addresses why the medical system doesn't embrace nutritional medicine as well as the system's apparent contradictions and vested interests. The book concludes with a brief outline of research into nutritional medicine and some of the supplements you can take to benefit your health. To finish, this book will also give the reader some information on what to supplement with. At this point it is important to note that I have not been paid by a supplement company to write this book. I wrote this book because I believe in the role of supplementation for sustainable health practices and personally supplement every day. Finally, one day I believe this book will be a required text for all students studying nutrition.

CHAPTER 2

OUR NEED FOR SUPPLEMENTATION

The term “supplement” refers to any product that supplies a specific dose of a vitamin, mineral, herb, botanical metabolite or food extract. It is generally recognised that our bodies require some 40 essential nutrients. These include:

16 vitamins;
12 amino acids;
Three essential fatty acids; and
20 or so minerals or trace elements.

Despite the controversy surrounding supplement use, two issues are widely agreed on by most researchers and health care professionals.

The first of these is that, where possible, nutrient intake gained through whole foods is generally of greater benefit to health than that achieved through supplements. Supplements should not be seen as an alternative to whole foods. So if it is widely recognised that supplements are not an adequate substitute for food, the importance of supplementation then lies in those cases where individuals do not, and in some cases cannot, achieve the nutrient levels required to maintain an optimum level of physical and mental wellbeing. Other cases include when supplement use will provide nutrients in concentrations that may facilitate the prevention of chronic degenerative diseases.

This leads us then to the second widely held view: that supplement use is almost always beneficial in cases where individuals have been shown to have a clinical deficiency for a given vitamin or mineral. That is, if someone is deficient in vitamin C, then supplementing with vitamin C will increase the levels and have some clinical health benefit.

Beyond that, there is an ever-expanding body of scientific evidence that shows the importance of nutrient supplementation, which I will present throughout this book. The science of nutrition is moving fast. For example, a simple search on PubMed shows the number of scientific articles on nutrition:

1970-1979 – 15,291 articles
1980-1989 – 28,673 articles
1990-1999 – 57,082 articles
2000-2010 – 112,674 articles

In addition there are literally hundreds of nutritional journals producing more articles each year.

To the benefit of the reader, privilege to this information has improved even further to the point that anyone with access to the Internet can find the latest studies through Google Scholar. Usually tens of thousands of articles and abstracts will be listed, so

you may need to be precise in selecting your search terms. This tool puts your health back into your hands and more unbiased information into the hands of our health professionals.

To deepen our understanding of why we need to supplement, the next chapter will explain that many of our current foods are depleted as a result of the overuse and misuse of our soils.

PART ONE

IF IT IS NOT IN THE FOOD, IT IS NOT IN OUR DIET

Over the past 100 years or so, our agricultural and food cultivation practices have changed so much and led to a substantial decline in the quality and quantity of nutrients we get in our food. They have allowed us to grow foods on nutrient-depleted soils, to literally mine the minerals out of the good agricultural areas and to destroy the quality of the soils. It takes only a decade to deplete soil of most of its nutrients. Even if minerals are available in the soils, farming practices have destroyed the quality of the soil so much that the plants may not even be able to take up the nutrients. This has led to a depletion of the basic nutrients in foods—including vitamins, minerals and antioxidants.

We no longer grow foods to be nutritious. Rather they are grown on mass scales with large quantities of poisons and additives so that foods will look good and be sold in supermarkets. The overuse of nitrogen fertilisers acts like salt drawing water into the plants: making them look tall and flush, perfect for the market, but full of little more than nitrogen salts and water. We have sacrificed the variety of crops and nutritional quality of the food in exchange for the convenience of growing it so that it is appealing to the eye.

This lack of nutrients in our food is further exacerbated by the fact that we pick unripened crops. These crops have higher levels of natural toxins and fewer ripened nutrients; then they are stored or travel thousands of kilometres to the marketplace. They are then processed and cooked so that any nutrients that were left in them are lost. A family looking for a nutritious meal might find its magnesium or selenium levels 10% of what they used to be, or vitamin C or B levels even nonexistent.

When we eat foods that are grown in depleted soil, picked too early to fully develop nutrients, then stored or processed until there is almost nothing left, we are getting little more than filler. In short: if nutrients are not in the food we eat, we must find them somewhere else. This is where supplements can help keep us healthy and even save our lives.

CHAPTER 3

IF IT'S NOT IN THE SOIL, IT'S NOT IN THE FOOD

The simplest concept to start with is that if nutrients are not in the soil, they can't be in the food. Veterinary surgeons and people in the animal husbandry industry have known this for decades. Many soils around the world are nutrient poor, but the advent of modern agriculture has enabled these areas to be farmed. Modern agriculture adds only what is required to make the food look suitable for consumption—particularly nitrogen, phosphorus and potassium[1]—not what is ideal for the plants and certainly not what is ideal for humans. Even nutrient-rich soils are quickly depleted with overuse and poor agricultural practices. Other farming practices, which are discussed later, also make the nutrients less available for plant uptake.

The minerals humans need to grow healthily include macro and micro minerals. Macronutrients include nitrogen, sulphur, potassium, calcium, phosphorous and magnesium. Micronutrients include iron, manganese, boron, chlorine, zinc, copper and molybdenum. Beneficial elements include sodium, silicon, selenium, cobalt, chromium and vanadium.

Globally, soils deficient in micronutrients are alarmingly widespread. Boron is one of the most prevalent micronutrient deficiencies.[2,3]Zinc deficiency is particularly common, with almost 50% of the world's cultivated soils being deficient.[4]Copper is deficient in many parts of the world where acid soils are used for agricultural production. Iron has been estimated to be deficient in approximately 30% of cultivated soils globally,[5]with similar trends for cobalt deficiency, manganese (Mn)[6]and molybdenum.[7]

Australia has the oldest and poorest soils in the world and is recognised globally for its nutrientdeficient soils and its relatively few areas of high soil fertility.[8,9]Western Australia in particular has been noted as one of the most trace element-deficient areas in the world[10,11]and it supplies a lot of Australia and other parts of the world with grains.

A read through any text on soils (e.g., *Soil Guide*) reveals potential mineral deficiencies in every soil type. During long periods of relative geological stability, as has been the case in Australia with no active volcanoes or major earthquakes, there is widespread deep weathering and leaching out of nutrients. The nutrients have, over millions of years, literally been washed out of the soils.

Mineral deficiencies in large parts of Australia include boron,[12,13]magnesium,[14,15,16]zinc,[17-21] copper,[22-26]iron (Fe),[27-31]cobalt (Co),[32-37]manganese (Mn)[38,39,40]molybdenum (Mo)[41-46]and selenium (Se).[47]These are all

essential nutrients for human health. It is worthwhile noting that selenium deficiency was discovered due to its deficiency in livestock, rather than plants, as it is an essential element in animals but not plants.

It is not just the minerals that are depleted in the foods grown in poor soils; other nutritional components such as vitamins and antioxidants may also be affected. The amount of total flavonoids (like beta-carotene) in fruit is significantly affected by the fertility of the soil. One study reported increases of two to three times the levels of these antioxidants by growing fruit in fertile soil compared to poor soil. Crops grown in soils deficient of copper, zinc or manganese have altered superoxide dismutase, which affects the plant's main antioxidants,[48]resulting in a reduction in the amount of antioxidants available to us from foods grown in these soils.

If nutrients are not in the soil, they are not in the food.

CHAPTER 4

DEPLETING THE SOILS EVEN MORE

It takes only a decade to deplete soil of most of its nutrients. Globally, soils have been depleted through their continual use for agriculture. The United Nations Health Summit has reported on the reduced quality of food and soil. Carrots contain 75% less magnesium and tomatoes contain 90% less copper compared to 30 years ago. More recently, one study estimated that the world average soil depletion of nutrients was 12.1 kg nitrogen per hectare, 4.5 kg phosphorus per hectare and 20.2 kg potassium per hectare; the study concluded that the majority of countries in the world deplete soils of nutrients for food production.[1]Increased food production worldwide has greatly increased the demands on soils for nutrients.[2]We are literally mining our soils of essential nutrients.

The most important loss of nutrients from cultivated soils is through crop removal. Table 1 shows the typical amount of nutrients removed by some agricultural products. If you grow a crop of wheat, it takes out 63 kilograms of nitrogen, 8 kg of phosphorus, 10 kg of potassium, and so on for each crop. Alfalfa takes out 95 kg of nitrogen and bananas 45 kg of nitrogen for each crop. While the nitrogen, phosphorus and potassium may be replaced with fertilisers, many of the micronutrients essential for human health such as zinc, manganese, copper and boron are not replaced.

Crop
Yield
Nutrient
Nitrogen (kg/ha) Phosphorus (kg/ha) Potassium (kg/ha) Sulphur (kg/ha) 4 Magnesium (kg/ha) Calcium (kg/ha) Zinc (g/ha)
Copper (g/ha)
Iron (g/ha)
Manganese (g/ha) Boron (g/ha)

Table 1. *Nutrient removal by crops and pastures.*
Source: Campbell 1998.[3]
Wheat Alfalfa Banana 2.5 (t/ha) 2.5 (t/ha) 45 (t/ha)

63 95 45 8 10 10
10 88 100 4 4 10 3 11 11 1 50 50
96 96 50 9 25 25 120 175 175 116 125 125 6 88 88

Historically, this loss of nutrients was recognised in Australia during the period from 1870 to 1900, when wheat yields declined by 57% until nutrients were added in the form of fertilisers.[4]We now add the basics for the plants to look appealing but not what humans need for optimal health.

Cropping systems

The type of cropping system used can affect soil fertility and soil microbes, with monoculture crops having the most impact on the ability of plants to produce and recycle nutrients.[5,6,7]Soil microbial biomass and activity (the bacteria, fungi and worms), which act as a source-sink for nutrients, are affected by different cropping systems.[8]Recent trends in Australia, the U.S. and other countries show that soil fertility has declined due to shorter rotations of pastures and increased use of monoculture.[9-12]

To put it all in perspective, 30 years ago, a woman could eat two peaches per day and get the RDA amount of vitamin A; these days she would have to eat 53 peaches for the same vitamin A content.[13] **CHAPTER 5**

BLOCKING THE NUTRIENTS

Unfortunately, even if minerals are available in soils, many other factors will determine a plant's uptake—including soil particle size, water content, acidity, aeration, organic matter and presence of other mineral ions. For example, if the uptake is an active process such as for potassium, low concentrations of oxygen in waterlogged soils will reduce this uptake; furthermore, large sources of calcium at the root surface are also thought to impede access to potassium.[1]An increase in zinc supply has also been shown to lead to a decrease in the calcium, potassium, magnesium and copper content of the leaves of the plant—all minerals vital to our health.[2]

Other factors that can reduce mineral uptake by plants include:

Particle size;
Water content;
Acidity (pH);
Pesticides;
Biological activity;
Aeration;
Organic matter;
The presence of other ions; Other minerals; and
Contaminants.

Of particular importance is the increasing nitrogen saturation and soil acidity, which have affected large areas of Australia and Europe as well as other parts of the world.
Soil acidification

Current agricultural practices have the potential to increase rates of soil acidification through the cultivation of legumes, application of ammonium fertilisers and removal of nutrients through cropping.[3-10]Indeed, soil acidification induced by agriculture is a national soil degradation issue in Australia. Table 2 shows the affected states.

Table 2*. Area of soil affected by acidity in Australia, including natural and induced.*

State
New South Wales
Victoria
Source: Evans 1991.[11]

Area affected
Nine million hectares (ha), which represents 50% of agricultural soils in eastern NSW
Five million ha, which represents one-third of the state's agricultural land

South Australia 0.4 million ha in the southeast of the state Western Australia Tasmania 1.0 million ha in the eastern Wheatbelt and around 0.5 million ha in the high rainfall southern region
Very small

Queensland Very small Acidified soils have a lower pH than normal, with normal being close to a pH of 7. This soil pH changes over time and is closely linked to the crops being used. Figure 1 outlines soil pH changes over a ten-year period according to the cropping system in place. Depending on the type of crop the pH of the soil becomes more acidic more quickly, that is, the pH gets lower and lower.

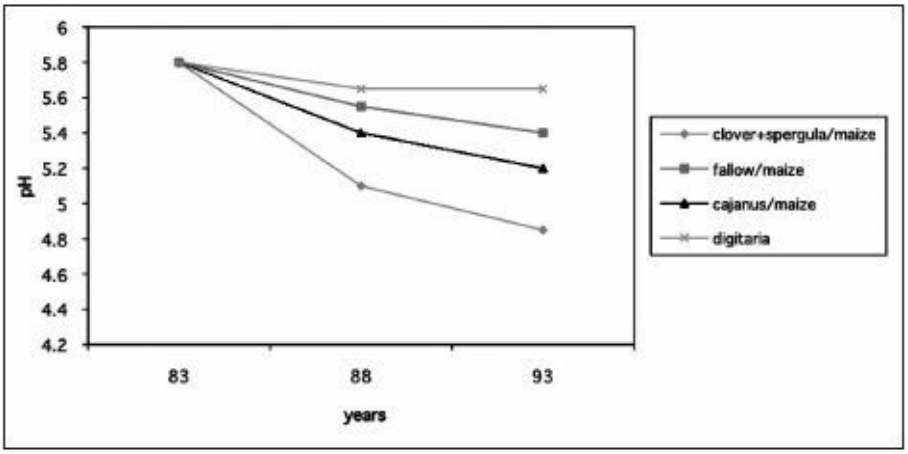

Figure 1. *Soil pH changes over a 10-year period due to cropping systems.* Source: Burle et al. 1997.

Soil acidity can have a dramatic effect on a range of nutrients, affecting their availability to plants. The main fertilisers, which contribute to acidity, are nitrogenous fertilisers and elemental sulphur. These acidic soils inhibit the uptake of Zn, Co and Se,[12,13] boron,[14] molybdenum[15,16] and manganese.[17]

It is estimated that about three million hectares of the sandplains of the Wheatbelt in Western Australia became deficient in molybdenum immediately after clearing, and the remainder developed molybdenum deficiency when acid-forming fertilisers were used.[18]While magnesium deficiency is not particularly widespread in Australia, agricultural practices have the potential to induce deficiencies through acidification.[19]Alkaline soils and soils which have been over-limed can become deficient in iron, copper, manganese and zinc.[20,21]

Highly acidic (low pH) soils can often result in the increase of toxic minerals such as aluminium. These soils can result in aluminium toxicity, which causes reduced growth in plants as well as deficiencies of other nutrients such as phosphorous.[22,23]At a critical pH, often around 5.5, sufficient aluminium becomes soluble and this is when it becomes toxic to plants. Manganese toxicity can also result from low pH.[24]

CHAPTER 6